DOCUMENT RESUME

ED 236 944 FL 014 110

AUTHOR	Duran, Richard P.; Enright, Mary
TITLE	Reading Comprehension Proficiency, Cognitive Processing Mechanisms, and Deductive Reasoning in Bilinguals. Final Report.
INSTITUTION	Educational Testing Service, Princeton, N.J.
SPONS AGENCY	National Inst. of Education (ED), Washington, DC.
PUB DATE	Aug 83
GRANT	NIE-G-80-0157
NOTE	164p.
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC07 Plus Postage.
DESCRIPTORS	*Bilingualism; *Cognitive Processes; Cognitive Tests; College Students; *Deduction; Higher Education; Language Proficiency; Mexican Americans; Problem Solving; *Reading Comprehension

ABSTRACT

The performance of 57 Mexican American bilingual college students on Spanish and English versions of problem solving tasks was investigated. The tasks included word recognition, sentence verification, reading span, syllogisms, and reasoning. The results indicated that the subjects used similar cognitive skills in performing both the Spanish and English language tasks. Although the subjects' reading and language proficiency was higher in English, they performed similarly in both languages. Their responses were as accurate in Spanish as in English, but slightly slower. It was concluded that bilingual students from strong educational backgrounds are effective in transferring cognitive skills from one language to another. The cognitive tasks are appended. (Author/RW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED236944

FINAL REPORT

National Institute of Education

Grant NIE-G-80-0157

READING COMPREHENSION PROFICIENCY, COGNITIVE PROCESSING MECHANISMS, AND DEDUCTIVE REASONING IN BILINGUALS

Richard P. Duran
Mary Enright
Educational Testing Service
Princeton, New Jersey

August 1983

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

FL014110

The research report herein was supported by the National Institute of Education grant NIE-G-80-0157 to the principal investigator through Educational Testing Service. The contents of this report do not necessarily reflect the position, policy, or endorsement of the National Institute of Education

Acknowledgements

Appreciation is extended to Blanca Gonzalez and Diana Corwin for their service as research assistants to this project. Thanks are also extended to Earl Hunt, Colin MacLeod, Valerie Reyna and Maria Elena Solis for their advice on the design of project tasks and materials. Any deviations from their advice are solely the responsibility of the original principal investigator, Richard P. Duran. Thanks are extended to Barbara Benton for her programming of microcomputer controlled tasks in this study, and also to David Saxe for his machine language programming of reaction time routines. Appreciation is also extended to Jessie Cryer, Christine Sansone, Faith Thompson, Joanne Farr, and Eleanor Hibbs for their secretarial services in preparing materials for the project and for their preparation of the final report.

Abstract

The performance of 57 Mexican American bilingual college students on Spanish and English versions of problem solving and reasoning tasks was investigated. The subjects were undergraduate students at a major Ivy League university and were more proficient in English than in Spanish. The purpose of the study was to investigate bilinguals' performance on Spanish and English versions of a set of cognitive and psycholinguistic tasks. Elementary cognitive tasks presented included a Word Recognition Task, a Sentence Verification Task, a Reading Span Task. Logical reasoning skills in Spanish and English were investigated using a Syllogisms Task based on the work of Johnson-Laird and Steedman, and two pencil and paper tests of reasoning.

The results of this research indicated that subjects utilized very similar if not identical cognitive skills in performing tasks in Spanish and in English. Although subjects' reading proficiency and general language proficiency was higher in English than in Spanish, the data tended to show that subjects performed similarly on cognitive and reasoning tasks in both Spanish and English. There was some evidence that while subjects performed as accurately in Spanish as in English, that performance was slower in Spanish than in English.

The data from this study indicate that bilinguals can be quite effective in transferring cognitive skills from one language to another--at least this may be the case with bilinguals with strong educational backgrounds and with verbal abilities in English that are relatively high compared to their bilingual population as a whole. Evidence was found which suggests that while speed of processing is slower in a less familiar language, accuracy of performance may be unaffected or affected only slightly. This speed accuracy tradeoff was most noticeable for a syllogistic reasoning task in the present study. The findings of this research thus support the hypotheses that bilinguals are more efficient in performing complex cognitive tasks in their more familiar language. The findings, however, also support the hypothesis that bilinguals may perform as accurately in their less familiar language when they possess an underlying mastery of the problem solving skills required by cognitive tasks.

Table of Contents

Chapter Page

1. Introduction 1-1
    A. Overview of Research 1-1
    B. Background and Motivation for Research 1-1
    References 1-4
2. A Framework for Cognitive Research on Bilingualism . 2-1
    Problem Sovling, Verbal Ability, and Language Proficiency 2-1
    Describing the Language Skills of Bilinguals 2-2
    A General Characterization of Problem Solving Processes 2-4
    Bilingualism Research Findings 2-6
        Problem Input 2-6
        Conceptualization and Mental Solution 2-10
        Language Production 2-12
    Conclusion 2-14
    Reference Notes 2-15
    References 2-17
3. Research Questions and Research Design 3-1
    A. Reading and Language Proficiency of Subjects . . 3-1
    B. Elementary Cognitive Tasks 3-4
        Word Recognition Task 3-5
        Sentence Verification Task 3-7
        Reading Span Task 3-8
    C. Logical Reasoning Tasks 3-9
        Syllogisms Task 3-10

Table of Contents (cont.)

Chapter Page

D. Relationships Among Tasks 3-14

References 3-16

4. Method 4-1

Apparatus 4-1

Subjects 4-1

Schedule 4-1

Instruments 4-2

Inference Test 4-4

Logical Reasoning Test 4-4

Cognitive Task Procedures 4-4

Word Recognition Task 4-4

Sentence Verification 4-6

Reading Span 4-7

Syllogisms 4-7

References 4-10

5. Results 5-1

A. Reading and Language Proficiency of Subjects . . 5-1

B. Elementary Cognitive Tasks 5-3

Word Recognition Task 5-3

Sentence Verification Task 5-6

Reading Span Task 5-13

C. Logical Reasoning Tasks 5-13

Syllogisms Task 5-13

The Effects of Mood 5-14

Table of Contents (cont.)

Chapter Page

The Effects of Figure 5-17

Predictions of the Analogical Theory 5-22

Logical Reasoning and Inference Tests 5-27

D. Relationships Among Tasks 5-27

Syllogisms Task and Reading and Reasoning Tests . 5-27

Syllogisms Task and Elementary Cognitive Tasks . 5-30

Tests of Reading and Reasoning and Elementary Cognitive Tasks. 5-33

References 5-42

6. Discussion 6-1

Major Findings and Patterns of Results 6-1

Reading and Language Proficiency Characteristics of Subjects. 6-1

Elementary Cognitive Task Performance 6-1

Logical Reasoning Task Performance 6-2

Relationships Among Tasks 6-4

Directions for Further Research 6-5

Implications from the Present Project 6-5

Needed Research 6-6

Reference Note 6-11

References 6-12

Appendix A

Logical Reasoning Tests: Cover Pages of Instruments A-1 - A-4

Table of Contents (cont.)

Chapter Page

Appendix B

Sentences Used in the Reading Span Task . . . . . . .B-1 - B-14

Appendix C

Syllogisms Task Materials . . . . .C-1 - C-25

LIST OF TABLES

Table Page

4.1 Testing Schedule 4-3

5.1 Comparison of Mean Scores on the Reading Comprehension Tests in English and in Spanish. . . .5-2

5.2 Sentence Verification Task: Mean Reaction Times and Error Rates for Significant Main Effects 5-9

5.3 Sentence Verification Task: Mean Reaction Times and Error Rates for the Response Type x Sentence Type Interaction. 5-10

5.4 Sentence Verification Task: Mean Reaction Times, and Error Rates for the Response Type X Sentence Type X Word Order Interaction. 5-12

5.5 Mean Percent Correct, Cochran's Q, and Mean Processing Time in Seconds for the Syllogisms in the Four Experimental Conditions 5-15

5.6 Correlations Between Total Correct Scores and Processing Time on Syllogisms Tasks. 5-16

5.7 Percentage Correct Responses in Terms of the Mood of the Premises 5-18

5.8 Correlations Among the Percent Correct for Items Classified by Mood of the Premises in the Johnson-Laird and Steedman Study and in the Present Study. 5-19

5.9 The Effect of Figure on the Form of the Conclusion . 5-20

5.10 The Effect of Figure on Accuracy 5-23

5.11 Mean Processing Time in Seconds for the Four Figures in Each Experimental Condition 5-24

5.12 Percent Correct Responses in Relation to the Predictions of Analogical Theory 5-25

5.13 Comparison of Performance on Spanish and English Version of the Logical Reasoning and Inferences Tests. 5-28

5.14 Correlations Between Performance on the Syllogism Task and on the Reading, Logical Reasoning and Inference Tests. 5-29

LIST OF TABLES (cont.)

Table Page

5.15 Correlations Between Performance on the English Versions of the Syllogism Task and the Elementary Cognitive Task 5-31

5.16 Correlations Between Performance on the Spanish Versions of the Syllogism Task and the Elementary Cognitive Tasks. .5-32

5.17 Correlations Among Performance on Reading, Logical Reasoning, Inference Tests and Elementary Cognitive Tasks for English Language Condition . . .5-34

5.18 Correlations Among Performance on Reading, Logical Reasoning, Inference Tests and Elementary Cognitive Tasks for Spanish Language Condition . . .5-38

LIST OF FIGURES

Figures Page

3.1 Four Question Areas, Tasks, and Issues of Research 3-2

5.1 ENGLISH WORD RECOG. TASK 5-4

5.2 SPANISH WORD RECOG. TASK 5-5

5.3 SP-ENG SENT VERFICATION. 5-8

Chapter 1

Introduction

A. Overview of Research

The research described in this report was designed as an investigation of how efficiently and accurately a group of Mexican American bilinguals could perform a variety of cognitive problem solving tasks presented in Spanish and in English. The study was motivated by a need to develop basic research findings on bilingual cognitive functioning utilizing methods of cognitive psychology as well as psychometrics. The questions of research centered on discovering how language of presentation affects bilinguals' performance on tasks based on performance models drawn from cognitive psychology. Overall, research about the influences of bilingualism on cognition has not been extensive from an information processing perspective, though some areas such as organization of bilinguals' semantic memory have received attention. The present study explored bilinguals' performance on several tasks which have been investigated intensively by cognitive psychologists working with monolingual adult subjects. The cognitive tasks under investigation included a Syllogism Task, Word Recognition Task, Sentence Verification Task, and a memory for verbal materials task known as the Reading Span Task. These tasks varied in their cognitive demands with some likelihood of overlapping processes across tasks. While the basic focus of the research was on studying performance on individual tasks across languages, one of the exploratory questions under investigation was whether performance on the Syllogisms Task might be significantly associated with performance on other tasks.

In pursuing study of performance on the tasks that have been mentioned two other basic issues were investigated. One issue concerned the relationship between reading skills in each language as assessed by a pencil and paper reading comprehension test, and performance on cognitive tasks. The key question here was whether a broadly based measure of verbal proficiency in a language was linked with performance on cognitive tasks. A second issue pertained exclusively to understanding performance on the Syllogism Task; the key question in this case was whether performance on pencil and paper tests of logical reasoning was associated with performance on the Syllogism Task.

B. Background and Motivation for Research

From the perspective of educational and social equity concerns, research on the cognitive functioning of bilingual persons in the U.S. is needed to establish a scientific collection of findings to aid educational practitioners, social scientists, and educational policy makers who must design, conduct, and evaluate educational programs that have bilinguals as participants. Recent Census Bureau estimates of the total U.S. Hispanic population are 13.2 million (U.S. Department of Commerce, May 1981). Among 11.2 million U.S. Hispanics in 1976, four out of five (8.9 million persons) resided in Spanish-speaking households, and one in three (3.7 million persons) usually spoke Spanish (Waggoner, 1978). These statistics are of particular educational and social significance when we note that persons from Spanish-language backgrounds enrolled in grades 5-12 were about twice as likely as pupils with English-language backgrounds to be two or more grades below the grade levels expected for their ages (U.S. Department of Health, Education and Welfare, NCES, 1978). Even among Hispanics who reported English as their primary language and who attained the ninth grade and continued on into high school, the dropout rate was double the dropout rate of English-only students. These demographic facts provide a sound reason for studying the cognitive functioning of U.S. Hispanic students to learn how performance on tasks related to schooling may be impaired or enhanced by requirements to perform in one language rather than another. While research on the learning problems and cognitive skills of young disadvantaged Hispanic children is important, basic research is also needed that focuses on Hispanics who are educationally advantaged relative to other Hispanics. Such research can help to develop a broader conception of how bilingualism interacts with cognitive functioning so that we may also account for the cognitive and linguistic abilities of bilingual persons who attain high levels of achievement within the mainstream education system. These individuals appear not to have suffered educational deficits because of their bilingualism. If this is true, we need to learn about such students' cognitive and linguistic processes so as to document the full range of bilinguals' educational potential. For example, recent theoretical writings and research on bilingualism (Cummins, 1978; Lambert, 1977) have found that bilinguals who are highly proficient in two languages may exhibit a concomitant enhancement of certain analytical and creative reasoning abilities.

Analyses of empirical data and factors affecting Hispanics' access to college, and achievement once in college, suggest that investigations of Hispanics should control for interHispanic group differences which are systematically related to the personal and background characteristics of Hispanic students. These include factors such as pattern of bilingual background and history of contact with U.S. schools (Duran, 1983). Accordingly, in investigating Hispanic bilinguals' cognitive skills it is helpful to study a relatively homogeneous group of Hispanics or to allow Hispanic subgroup identity to be a variable under investigation.

In the present research one Hispanic subgroup, Mexican Americans, was investigated. The population under study was undergraduate students attending an Ivy League college. This cohort of students is an important one in that it represents a subgroup of about 80-90 students out of about a total of 200 Hispanic students who are largely present in the institution in question because of targetted admissions recruiting procedures. Before 1975, Ivy League colleges had virtually no U.S. native Hispanic students in attendance. Presently almost all U.S. born Hispanics in Ivy League colleges are there because of special recruiting efforts. The admissions policy for Hispanic students at Ivy League schools does not always weigh admissions test scores and high school grades of targetted applicants in the same ways as other candidates for admission. Nonetheless, the Hispanic students who are admitted possess traditional academic preparation credentials which are among the highest found among Hispanics college candidates. The occurrence of bilingualism among this group of students ought to show special characteristics; these students have have a very strong academic background in English and are more likely to show greater familiarity with literate use of English than Spanish. Accordingly, an important question for research is the extent to which such students can demonstrate as effective problem solving in Spanish--their less familiar language as in English--their more familiar language.

The educational implications of research on students such as these is that we will extend our knowledge of how cognitive processes are affected by problems posed in different languages. We will learn how problem solving skills are organized in bilinguals. Furthermore, we will increase our understanding of how important language is to the performance of cognitive tasks that are theorized to involve component skills which are either directly or only indirectly connected to language processing. Apart from a contribution to knowledge about Hispanics, this research will suggest hypotheses which might be investigated with foreign students who enter the U.S. with a strong academic background in a non-English language. The findings of this research will help us to formulate hypotheses concerning the ability of foreign students to apply cognitive skills acquired through experience in their native language to academic experiences occurring in English. Such extensions, however, are fraught with complications due to problems such as similarities and differences between English and the native language of students. These and other issues regarding interpretation of bilinguals problem solving behavior are discussed in the next chapter.

References

Cummins, J., 1978. Bilingualism and the development of metalinguistic awareness. Journal of Cross-Cultural Psychology, 9, 131-149.

Duran, R. P. Hispanics' education and background: Predictors of college achievement. New York: College Entrance Examination Board, 1983.

Lambert, W. The effects of bilingualism on the individual: Cognitive and sociocultural consequences. In P. Hornby (Ed.), Bilingualism: Psychological, social and educational implications. New York: Academic Press, 1977.

U.S. Department of Commerce, Bureau of the Census, 1981. Persons of Spanish origin in the United States: March 1980 (Advance Report), Population Characteristics, Series P-20, No. 361. Washington, DC.

U.S. Department of Health, Education, and Welfare, National Center for Education Statistics, 1978. The educational disadvantage of language-minority persons in the United States, Spring 1976, No. 78 B-4. Washington, DC.

Waggoner, D. Non-English language background persons: Three U.S. surveys. TESOL Quarterly, 12(3), 1978, 247-262.

Chapter 2

A Framework for Cognitive Research on Bilingualism

The research described in this report is organized according to a conception of how bilingualism might affect cognitive behavior. The present chapter presents this framework and introduces the major issues which motivated selection of the cognitive and problem solving tasks for investigation in the present project. These issues include: a) associations between problem solving, verbal ability and language proficiency; b) description of bilinguals' language skills; c) a general model of steps in problem solving; and d) a description of some previous research on bilinguals' problem solving from an information processing perspective. The specific research questions and design are discussed in the next chapter.

Problem Solving, Verbal Ability, and Language Proficiency

Psychometricians have long recognized a connection between performance on tests of verbal skill and performance on tests of general cognitive ability. Measures of verbal ability are strongly predictive of a wide range of problem-solving and reasoning skills. Of course, the application of these general findings to bilingual persons is no simple matter. Cognitive psychologists and psychometricians have used the term verbal ability to refer broadly to language skills. In contrast, researchers in the area of bilingualism and language assessment traditionally have used the term language proficiency to denote familiarity with a language system. Although the terms are related, the connotations are different. Language proficiency usually refers to elemental skills in controlling the basic phonological, morphological, lexical, and grammatical units of a standard variety of a language. Language proficiency is seldom applied in reference to the language skills of a native speaker of a language; instead, it usually refers to the language skills of a person who does not manifest native-like skills. The term verbal ability tends to refer to a continuum of language skills that are manifested by native speakers. However, recent efforts to extend measurement to the assessment of more complex and advanced forms of proficiency tend to break down this distinction. Advanced levels of language proficiency seem to be a manifestation of a single, underlying language factor called integrative proficiency (Oller, 1979). This refers to the coordination of multiple language skills in the service of performing everyday pragmatic tasks with language. Oller has found that scores on tests designed to measure integrative proficiency correlate highly with performance on tests of general cognitive abilities.

Nevertheless, it is obvious that measures of language skill do not have precisely the same significance for bilinguals as indicators of cognitive ability, nor would one expect them to predict problem-solving performance in the same way or for the same reasons. Typically, a person will manifest stronger familiarity and proficiency in one language than in another. Relatively few persons come to demonstrate equal strength and fluency in more than one language system, and this implies that most bilinguals do not attain native-like proficiency in at least one of their languages. Still, it may be presumed that there is an overlap in language skills across two languages and that a single language-skill factor may exist. That is, problem-solving performance in a bilingual individual may be affected by specific language skills in the language in which the problem is presented, by general linguistic, comprehension, or representation skills that are mostly independent of the particular language being used, and by nonlinguistic cognitive abilities that benefit from the cognitive functions exercised in becoming bilingual. Consequently, a general language-skill factor is probably not refined enough to capture how ability in a language affects performance on problem-solving tasks. Performance on tasks presented in a particular language cannot be predicted in detail from a single measure of proficiency in that language. Both a refined description of language proficiency and a good analysis of the way different aspects of language proficiency interact with the information-processing demands of problem-solving tasks are required in order to understand the problem-solving performance of bilinguals. It is necessary to specify more carefully what modality of language and linguistic code is involved and how specific recognition and transformation of a linguistic code affects performance of steps in a particular problem solving task. These matters are taken up in more detail in the remainder of this chapter. First, however, a brief discussion of efforts to characterize the language skills of bilinguals and the general nature of problem-solving tasks will be presented.

Describing the Language Skills of Bilinguals

An essential perspective on bilingualism is a linguistic one that deals with the description of and contrast between the formal structures of two languages and how this contrast may affect the development of bilingualism and skill in two language systems. Personal and psychological characteristics of a language learner, such as age and cognitive level of development, must also be taken into account. An excellent recent review of these issues is provided by Hakuta (Note 2).

According to Hakuta, an adequate psychological account of language acquisition by bilinguals ought to be able to capture how an individual develops, interrelates, and maintains models of two separate language systems. Since language systems exist outside of a single individual, the similarities and contrasts between two language systems predetermine some of the problems (or even advantages) that a language learner faces in acquiring a second language. The following list is given by Hakuta (1981, p. 24), as an example of some major structural variables which differ or are similar across language systems: (a) position (postposition/preposition), (b) branching direction (left branching/right branching), (c) word order variability (rigid word order/free word order), (d) dummy subject (has no dummy subjects/has dummy subjects), (e) object-verb order (verb-object/object-verb), (f) agreement (has no subject-verb agreement/has agreement), and (g) passivization (has no passives/ has passives). Hakuta suggests that languages cluster together in terms of their realization of general structural variables such as those listed. He also suggests that the psychological process of acquiring a new language reflects the contrast in features between a new language and old language as well as the strategies and processes that thus help in acquiring the new language. The foregoing discussion is relevant to the study of bilinguals' problem-solving ability in each of two languages. In effect, bilinguals' skill in utilizing a new language or a less familiar language will depend on the degree to which the new language has been acquired. Difficulties which a bilingual has in a new language may reflect knowledge of a more familiar language and the extent to which knowledge of a new language has become independent of the more familiar language. In the long run, if we wish to understand how knowledge of a less familiar language constrains problem solving in that language, we need to work from a linguistically powerful model of persons' knowledge of two language systems.

As part of this research goal, we will also need to know a lot about language-use strategies employed by bilinguals as they deal with a less familiar language. The range and types of strategies that may occur is large; just a few will be mentioned here. For example, bilinguals who are very weak in one language may mentally translate information from a less familiar language to a more familiar language. Or when encountering words that are unfamiliar in one language, bilinguals might substitute for them the meanings of words from another language. The basis for the substitution may be a judgment that the unrecognized word is equivalent to a word found in the other language, or else that the unrecognized word has the same etymology as a word in the other language.

Transfer of knowledge of language structure from one language system to another is likely to be most noticeable in production of speech or writing. Awkward or incorrect syntax and word usage in writing or speech may reflect a strategy of transferring structures and word knowledge from one language to another. Although infelicities in production of a less familiar language may reflect knowledge of another language system, it is also possible that infelicities are evidence of generalization strategies helpful in learning to use a new language. An erroneous use of a generalization strategy, for example, occurs when a language learner encounters a novel linguistic situation and tries to apply a grammatical rule that applies some, but not all, of the time in a new language. In English a classic example of this occurs when the suffix "-ed" is inappropriately appended to a verb root to form the past tense of a word, as in "speaked" or "breaked." Generalization strategies are necessary in all language learning; still, such strategies may result in erroneous description or interpretation of problem-solving information in a less familiar language.

Bilingualism also has significant social and cultural dimensions, affecting not only the varieties of the two languages that persons acquire, but also the situations and circumstances that accompany preference for use of one language versus another, including the possibility of intermixing codes. The sociocultural aspects of bilingualism are a significant determinant of how fluent a person becomes in each of two languages. These topics are discussed briefly in the concluding section of the final chapter.

A General Characterization of Problem Solving Processes

In further elaborating ways in which familiarity with two language systems may affect problem solving, it is helpful to outline an overview of problem-solving behavior consistent with an information-processing description of cognition. The second step is to isolate some information-processing behaviors that may show the influence of language familiarity on overall problem-solving performance. Next, relevant findings from existing research are used to illuminate the issues introduced.

Formal problem-solving situations, such as those encountered in academic settings, may be partitioned into three interactive sets of activities: problem input, problem representation and conceptual solution, and physical execution of solution steps. Problem input refers to a person's initial perception and interpretation of information in the physical environment defining a problem-solving circumstance. The second activity, problem representation and conceptual solution, refers to the purely mental acts that a person undertakes in solving problems. The third set of activities, physical execution of solution steps, refers to behavioral acts performed by a person in working with problem information in the external physical environment; some of these acts result in physical proof of a completed correctly or incorrectly solved problem. In this chapter, concern for the third step will be restricted to speech or writing in problem-solving contexts. The three sorts of problem-solving activities mentioned are not necessarily sequential, though for very simple problems they might be. By segregating these activities, we can distinguish ways in which langage processing may be implicated in problem solving.

In information-processing accounts of problem solving, such as those advocated by Newell and Simon (1972), the primary concern is with how problem representation and conceptual solution occur and are organized. In the Newell and Simon account, problem-solving behavior requires a clear idea of the conceptual state of affairs defining a problem, the conceptual state of affairs conforming to a solved problem, and the conceptual operations that are legitimate in creating intermediate problem states on the path to a solution. These three constraints on conceptual problem representation and solution fulfill in part Newell and Simon's notion of what constitutes a well-structured problem. Another aspect of a well-structured problem includes a match between conceptual problem information and states of affairs in the problem's physical or real-world task environment. This latter aspect of problem solving is responsible for guiding the physical execution of problem-solving steps and the production of language as required.

Conceptualization and solution of a problem is said to occur in a problem space or mental scratch pad in short-term memory that represents problem information. Thus, solution of a problem is affected critically by a person's ability to formulate a valid and tractable mental representation of a problem and its demands. A person's knowledge that is relevant to constructing a problem space is a key element in problem solving. A second key element is the mental resources that he or she may exercise in executing the mental operations required in problem solving. Availability of cognitive resources such as speed in information processing, short-term memory capacity for problem information, and capacity to maintain and direct immediate attention for problem information are important indicators of problem-solving ability that may be sensitive to language-processing skills.

A central issue for discussion in this chapter is the affect of language skills on problem-solving behavior and the concurrent links between overt measures of problem performance and cognitive processes. Overt measures of problem performance such as correctness of problem solution, speed in arriving at a solution, and sequence of actions and verbalizations enroute to solution of a problem need to be linked to reasonably explicit models of how language proficiency may affect not only overt behavior but also covert information-processing behavior. One valuable approach to these issues is to analyze performance on problem-solving tasks in terms of task structure and requirements and in terms of linguistic skills needed to meet task demands. The next section describes research on how language skills affect bilinguals' performance of the three key problem-solving activities: problem input, problem representation and conceptual solution, and language production.

Bilingualism Research Findings

Problem input. Problem input is a receptive process by which a problem solver acquires information about problems. It is obviously dependent on skill in decoding and understanding the linguistic description of a problem and its accompanying instructions. For bilinguals, we expect that verbal problem information would be easier to decode and understand in the more familiar language. Bilinguals should be faster and more accurate readers in a more familiar language than in a less familiar language. Furthermore, they ought to be better at comprehending oral speech and at making phonemic discriminations in a more familiar language. If we were able to control for similarity of bilinguals' and monolinguals' familiarity with a problem domain and for differences in other individual characteristics across these two groups, we would expect that monolinguals would likely be more efficient in decoding verbal problem information in their single language than bilinguals in this same but less familiar language.

The bilingualism research literature does provide findings that support the foregoing hypotheses. Lambert (1955) found that bilinguals showed slower reaction times to simple oral instructions in a less familiar versus more familiar language. Subjects in this study were instructed to press one of a number of keys, coded by a color and digit number, when told to do so in one language versus another. In this study, within-subject differences in response speed were not studied in relation to degree of assessed proficiency in the less familiar language. Dornic (Note 3), using a task somewhat similar to Lambert's and a within-subject research design, found that bilinguals performed more slowly in a less familiar language than in a native language. He found evidence that differences across languages in reaction time to oral instructions decreased as self-judgements of proficiency level increased in the less familiar language.

Attention to bilinguals' efficiency in recognizing language has led to concern for the structure of their semantic memory. The major issue has been whether bilinguals maintain one or two separate memory systems for word meanings. Contemporary cognitive theory would suggest that the conceptual knowledge referred to by words is stored in a single long-term memory system, regardless of the language in which words are input. An alternative to this view is that bilinguals maintain separate memory systems for the meaning of words in each language. Thorough reviews of research in this area are provided by

McCormack (1977), Dornic (Note 3) and Lopez (1977). Results of studies tend to support the hypothesis of a single semantic memory system for words from two languages. Some of the major results are summarized succinctly by Dornic (Note 3) as follows:

> By far the largest amount of the bilingual memory research to date has given support to the common-store hypothesis. Kolers (1966b) was the first to demonstrate the "bilingual equivalence effect" (i.e., that translation equivalents behave as old items) in short-term memory. Kintsch (1970) observed false recognitions of translation equivalents, and Kintsch and Kintsch (1969) found interlingual interference in pair-associate learning. Young and Saegert (1966) and Young and Webber (1967) observed that associations formed in one language can interfere with, or facilitate, the formation of new associations in another language. Young and Navar (1968) demonstrated interlingual retroactive inhibition: they showed forgetting in one language to occur as a function of associations formed in the other language. Lopez and Young (1974) found positive transfer effects to be uniform both between and within languages. In a novel type of bilingual memory experiment, MacLeod (1976) using the "savings method" as a measure of long-time retention, also provided support for the common-store theory. (p. 21)

One interesting approach to the question of bilinguals' semantic memory organization has been based on a monolingual word-recognition paradigm developed by Meyer and Schvaneveldt (1971). These investigators simultaneously presented pairs of word-like stimuli to monolingual subjects via a tachistoscope; the task of subjects was to respond "Yes" or "No" depending upon whether both stimuli were words or not. It was found that correct "Yes" responses were faster for words that were semantically related (e.g., "doctor-nurse") than for words that were not obviously related (e.g., "doctor-chair"). This effect is interpreted to reflect the association of meanings among words in semantic memory. Words that are related are recognized faster because once a single word has been recognized, access to its semantic associates is heightened. This facilitation is an effect of the organization of memory for word meanings and not only of ability to recognize that letters are appropriately combined to form a word.

Palij (Note 4) in a recent study found a semantic facilitation effect in a mixed French-English bilingual version of the Meyer-Schvaneveldt word recognition task. In this task subjects were simultaneously presented with a word in one language and another word that was sometimes in the other language. Subjects were faster at recognizing word pairs in different languages when the words from different languages had meanings that were highly related. An earlier study by Meyer and Ruddy (Note 5) reported a similar finding with mixed English and German words. These results support the hypothesis that word meanings in different languages are represented by the same underlying system of semantic memory. Citing Hines (1978), Palij suggests that evidence for a single-store model of bilingual semantic memory may be further refined if consideration is given to perceptual word-recognition strategies which are language specific. Varying the orthographic and phonological difficulty of words may lead to differences in performance on a paired word recognition task. Speed of performance on mixed language versions of the Meyer-Schvaneveldt word-recognition task may be affected by bilinguals' word decoding efficiency in each language and not only by the presence or absence of an obvious semantic association among words.

The present research project investigated bilingual Mexican Americans' speed in recognizing word and word-like pairs of stimuli in either Spanish or English. A pure rather than mixed-language version of the Meyer-Schvaneveldt word recognition task was used. In the pure version, subjects only worked experimental items drawn from materials originating in each language separately. The purpose of administering the Meyer-Schvaneveldt word recognition task to subjects in the present study was to assess their relative speed across languages in accessing words given only their graphemic code.

The previous discussion has concerned bilinguals' efficiency in recognizing words and word meanings in a less familiar language. Attention is now turned to bilinguals' efficiency in recognizing sentence and text-length materials. It is difficult to separate reading efficiency as a purely input process in verbal problem solving from conceptual utilization of verbal information in problem solving. This is because performance in reading is always influenced by the contextual demands of reading and because measurements of reading efficiency may accordingly require persons to do some problem solving based on understanding language in order to generate performance measures. For the moment, however, attention will remain on reading efficiency for sentence-length materials where problem solving is kept at a minimum; this is more in line with a focus on input processing of language, rather than problem solving as an extended conceptual process affected by linguistic skills.

The conclusion that bilinguals read sentence-length materials slower in a less familiar versus more familiar language has long been established in research on bilingualism (e.g., see Kolers, 1966a; and MacNamara & Kellaghan, cited in MacNamara, 1967). The importance of efficiency in reading comprehension in a less familiar versus more familiar language for foreign students' schooling has also been investigated. Angelis (Note 6), for example, has found that graduate foreign students in business and engineering judge that limits in reading efficiency pose the most serious linguistic difficulties for students. Despite occasional forays in the area, not too many comprehensive studies of bilinguals' reading efficiency have yet been done from a contemporary information-processing perspective.

One strategy for proposing and beginning such research might start by replicating well-known monolingual sentence verification experiments with bilingual subjects. The objectives of such research would be to study what linguistic and task characteristics affect bilinguals' ability to recognize and utilize semantic information in one language versus another. This strategy is pursued in the present project by examining Hispanic bilinguals' performance on Spanish and English versions of the Reading Span task (Daneman & Carpenter, 1980) and the Clark and Chase (1972) Sentence Verification task.

The Daneman and Carpenter Reading Span task assesses subjects' memory span for individual words occurring in a sequence of sentences. Subjects are asked to recall, in order, the last words of a set of sentences, where the number of sentences in a set may vary from two to six. Daneman and Carpenter found that accuracy of performance in this task was strongly related to individual differences in verbal aptitude as assessed by a number of measures, including Verbal SAT scores.

In the present study a bilingual version of the original Daneman and Carpenter Reading Span task was created and administered via a microcomputer. Performance in Spanish and English was studied in order to reveal whether subjects had greater memory for words in English than in Spanish and whether performance had a significant relationship to reading comprehension test scores and other measures.

In Clark and Chase Sentence Recognition task subjects are presented with sentence-figure pairs in each language and asked to determine whether they match. Sentences are presented first, followed by figures. Sentences are very simple, such as "Star above Plus" or "Star not above Plus"; figures are of a form such as $\begin{smallmatrix}*\\+\end{smallmatrix}$ or $\begin{smallmatrix}+\\*\end{smallmatrix}$. The subject's task is to respond true or false as quickly as possible. Previous research by Clark and Chase (1972) has confirmed that speed in decision making in this task can be explained by an explicit information-processing model describing the linguistic structure of sentences, the correspondence between sentence forms and figures, and the decision-making steps required. In the present project, it was possible to investigate whether bilinguals' performance on the Clark and Chase sentence verification task was similar across Spanish and English modes of task presentation.

Research such as the foregoing is valuable because it helps pinpoint explicit ways in which bilinguals' recognition and simple understanding of language is affected by the language of problem presentation. On the basis of such research, we can understand ways in which efficiency in language comprehension can be expected to vary and not vary on the basis of differential familiarity with two languages. Attention now turns to effects of linguistic familiarity on complex problem solving.

Conceptualization and mental solution. The solving of complex problems may be affected by language familiarity in two basic ways. First, following from the discussion on input processing of language, the appropriateness and sophistication of the mental model of a problem will be directly related to quality of comprehension of a problem statement, which in turn is based on a person's familiarity with the language system used to input a problem. Secondly, there may be a need to rely on knowledge of language during conceptual problem solving that goes beyond the original need to understand a problem as it is originally stated. Thus, conceptual problem solving may be affected by familiarity with a language. The basic question addressed here is: In what ways may bilinguals vary in their conceptual problem-solving activities given their degree of familiarity with two languages?

This research question has not been investigated intensively in bilingualism research despite its importance, though there are some classic investigations to note. MacNamara (1967,) as part of a series of 22 studies of English-Gaelic bilinguals' mathematical skills, found that bilinguals performed better on mechanical arithmetic problems involving no verbal materials than on verbal arithmetic problems in their non-native language, Gaelic. When bilingual subjects were compared to monolingual subjects they performed at a similar level on mechanical arithmetic problems, but more poorly on verbal mathematics problems. MacNamara (1967) concluded that the observed pattern of results was

> probably due to the fact that in mechanical math the student is simply required to carry out an arithmetic operation indicated by an arithmetic symbol, whereas in tests of problem [i.e., verbal arithmetic he is required to read and interpret prose passages.] (p. 122) (Bracketed material added for clarification.)

MacNamara believed that ability to understand individual sentences in a problem statement was inadequate to account for differences in problem solving such as those mentioned. MacNamara and Kellaghan (cited in MacNamara, 1967) investigated whether bilinguals' understanding of the subparts of a verbal problem equally well in two languages would be followed by an equivalent success rate in solving a problem completely in two languages. The verbal problems used were based on everyday knowledge. The study involved 341 sixth-grade Irish children who were native speakers of English but who had received instruction in both Gaelic and English. Subjects were divided into two groups; one group was presented with problems only in English and the other group received problems only in Gaelic. The results showed that understanding the meaning of individual sentences in a problem (as measured by an ability to answer very simple questions about their meaning) did not lead to an equal success rate in solving all problems presented in two languages. The study found that a smaller proportion of subjects succeeded in solving some problems completely in Gaelic than they did in English, despite the fact that only the performances of subjects who understood the sentences equally well in both languages were compared. Recall that comprehension was gauged by the ability to answer simple questions about the meaning of sentences; a more demanding standard of comprehension might have been needed.

In a very recent study, Mestre, Gerace, and Lochead (Note 7) investigated Hispanic engineering students' ability to convert linguistic statements of very simple verbal algebra problems in either of their two languages into equations. The results suggested that the balanced bilingual subjects showed equal facility in converting verbal problems into equations across their two languages and, further, that they tended to make similar types of errors across two languages. In addition, however, bilinguals were found to perform more poorly on the task than a comparison group of monolingual English subjects. For both monolingual and bilingual English groups, success in representing verbal problems as equations was significantly predicted by reading comprehension proficiency in each language, with this relationship being noticeably stronger for bilinguals than for English monolinguals.

I (Duran, 1981, Note 8) investigated similarities in the performance of adult Hispanic bilinguals on four matched, Spanish-English tests of logical reasoning. Factor analytic study of the tests that were administered had led to the conclusion that the tests identified the same underlying cognitive factor in their English versions (Ekstrom, French, & Harman, Note 9; French, Ekstrom & Price, Note 10). The results of this study indicated that subjects performed similarly on translated versions of the same tests in two languages, though they would perform more poorly in the language they were least proficient in. The evidence supported the possibility that bilinguals were applying similar strategies in working highly related reasoning ~~problems in~~ two languages, but that reading comprehension ability in each language moderated performance in each language. Substantial correlations between reading comprehension test scores in any one language and logical reasoning test scores in the other language for both Spanish and English were also found. These results suggest that there are skills or abilities common to reading comprehension and to the solution of reasoning problems that are quasi-independent of a language required for problem solving, as discussed earlier in this chapter.

The present project went on to investigate Hispanics' ability to solve logical reasoning problems in English and Spanish in a manner augmenting some of the research which has been described. Rather than using only pencil and paper tests of reasoning, logical problems--syllogisms were presented in a systematic way sampling their characteristics as a problem type. Previous research of Johnson-Laird and Steedman (1978) investigated monolingual college students' ability to draw correct conclusions from syllogism premises and student's propensity to render some conclusion types over others. Johnson-Laird and Steedman proposed an information processing model accounting for the performance of their student subjects. The present project replicated parts of Johnson-Laird and Steedman's research design with bilingual subjects. Johnson-Laird and Steedman found that the order in which information was presented in syllogism premises affected the characteristics of the most frequent conclusions which subjects drew. They also found that syllogisms involving more intermediate steps and verification steps were harder than other syllogisms.

In the present project it was possible to study Hispanic bilingual college students' performance on syllogism problems with an experiment resembling the research design of Johnson-Laird and Steedman. The experiment inquired whether bilinguals performed similarly when presented syllogism problems in each of their two languages and whether the performance of subjects resembled the performances that Johnson-Laird and Steedman had encountered. The issue under investigation was the extent to which bilinguals' performance on a complex problem solving task, requiring reading of problem information was affected by the language in which problems were presented. It was hypothesized that subjects' performance would be more accurate and efficient in English than Spanish, though the degree of these differences might vary accoring to the complexity of syllogism problems.

Language production. The impact of ability to produce language in solution of complex problems has received only limited attention in the cognitive bilingualism literature. Two issues seem apparent. First, there is the question of the ability of bilinguals to encode information in language in order to communicate such information publicly, as may be required in a problem-solving task. A second issue concerns the quality of the language produced in these circumstances. The second concern is essentially about the intelligibility of language; this intelligibility may be influenced both by skill in encoding thought into language and also by the ability of a bilingual to modulate speech and writing in ways that conform to the phonology and orthography of a language. Overlaying both issues are discourse skills that determine the effectiveness of communication given a setting, activity, and purpose for communication.

As with analysis of bilinguals' input capabilities with language, there is no clear separation between bilinguals' ability to conceptually solve problems and ability to produce appropriate language as required by problem solving. Especially in complex problems, a clear verbal formulation of the problem may be an important part of the thinker's representation and solution process. The examples of research discussed briefly here do not derive from information-processing psychology, but they suggest future research that might be undertaken from that perspective. The two problem contexts considered are writing on essay topics and answering questions in a psychiatric interview.

Studies of the English composition skills of persons with bilingual background suggest that errors in composition can reflect not only lack of familiarity with English but also lack of skill in organizing a composition to convey required information. Errors of the former sort have been studied, e.g., by Herrick (Note 11), with Mexican-Americans writing in English. Herrick noted that his informants made errors that showed clear transfer of knowledge of Spanish into English. Some errors had an authentic orthographical origin, for example, English words such as comfort would be spelled as 'confort," stemming from the Spanish word confortable of the same meaning. Other sorts of writing errors showed transfer of phonology from Spanish to English. For example, an incorrect phrase such as "I used to leave here when I was younger" might reflect a substitution for 'live' based on pronunciation. Herrick diagnosed that incorrect writing errors of this sort arise because some Hispanics may pronounce the English "living" as "leaving" because in Spanish, "i" is pronounced like the English "ea" in leave. Randle (Note 12) studied the writing problems of Mexican-Americans from Spanish language backgrounds. She found that awkward rhetorical organization, lack of clarity of expression, and other shortcomings in discourse structure limited the quality of their English essays. These latter errors were as notable as errors that appeared to stem from inappropriate transfer of Spanish structures to English. Randle suggested that to improve writing skills of bilingual children, production of whole essays, where the objectives and purposes of writing guide the writing behavior should be stressed. In her opinion, emphasis on eliminating grammatical errors and spelling errors and improving vocabulary does not accomplish enough in training bilingual children to write entire essays well.

Another example of how problem solving may be affected by bilinguals' fluency in a language focusses on speech behavior in psychiatric diagnosis. Marcos and Trujillo (1981), psychiatric practitioners reviewing their own work in this area, found that Spanish-dominant patients were often diagnosed inappropriately if their psychiatric interviews were conducted in English rather than Spanish. They found that patients, when asked questions in English, spoke more slowly and evidenced less skill in diction and less coherent development of their thoughts than in Spanish; this occurred despite the therapeutic context of interaction. One interesting observation of Marcos and Trujillo was that some Spanish-dominant patients evidenced more gestures and motor movements while speaking in English than in Spanish. Marcos and Trujillo suggest that such accentuated movement is indicative of stress when operating in a less familiar language; the gestures and movements indicated the exercise of deliberate motor strategies to assist in communicating meaning and to control the physical execution of speech. Dornic (Note 3) has suggested that information-processing models of bilinguals' language behavior should take into account the stress load or perceived difficulty of performing language tasks. Attentional demands required to comprehend or produce a language as well as allocation of physical and mental resources to performance of language related tasks may affect the pool of cognitive resources (e.g., memory and attention) that can be used during problem solving in a language.

Conclusion

This overview of bilinguals' problem solving indicates that degree of ability to solve problems in a less familiar language can often be traced to fairly specific behaviors involving language processing and its impact on cognition. Analyses and assessment of bilinguals' cognitive skills will need to be guided by the development of an extensive body of research findings such as those discussed in this paper. Further information-processing research on bilingualism appears to be a very important route to refining our understanding of these issues. At present, much bilingualism research on cognition is unsophisticated, and it seldom draws on information-processing paradigms for research. This chapter suggests that it is possible to join research on bilingualism with research on information processing, though this task requires expertise in linguistics and language assessment as well as in cognitive psychology. The next chapter of this report discusses the major research questions and research design of the present project in light of the discussion of the present chapter.

References Notes

1. Duran, R. P. *Hispanics' education and background: Predictors of college achievement*. New York: The College Board, 1983.

2. Hakuta, K. *The second language learner in the context of the study of language acquisition*. Paper presented at the Society for Research in Child Development Conference on Bilingualism and Childhood Development, New York University, June 25-26, 1982.

3. Dornic, S. *Information processing and bilingualism*. No. 510, Reports from the Department of Psychology. Stockholm Sweden: Department of Psychology, University of Stockholm, 1977.

4. Palij, M. *Semantic facilitation on a bilingual lexical decision task*. Paper presented at the Eastern Psychological Association meeting, April 1980.

5. Meyer, D. E., & Ruddy, M. G. *Bilingual word-recognition: Organization and retrieval of alternative lexical codes*. Paper delivered at the Eastern Psychological Association meeting, April 18-20, 1974.

6. Angelis, P. *Language skills in academic study*. Princeton, NJ: Test of English as a Foreign Language Program, Educational Testing Service, unpublished manuscript, 1982.

7. Mestre, J. P., Gerace, W.J., & Lochhead, J. *The interdependence of language and translational math skills among Hispanic engineering students*. Unpublished manuscript, University of Massachusetts, Department of Physics and Astronomy, 1980.

8. Duran, R. P. *Logical reasoning skills of Puerto Rican bilinguals*. Final Report to the National Institute of Education. Princeton, NJ: Educational Testing Service, 1979.

9. Ekstrom, R. B., French, J. W., & Harman, H. H. *Manual for kit of factor-referenced cognitive tests*. Princeton, NJ: Educational Testing Service, 1976.

10. French, J. W., Ekstrom, R. B., & Price, L. A. *Manual for kit of reference tests for cognitive factors*. Princeton, NJ: Educational Testing Service, 1963.

11. Herrick, E. M. *Spanish-English orthographic issues in English composition*. Paper presented at the Conference on the Investigation of Form and Function in Mexican-American (Chicano) English, University of Texas at El Paso, September 10-12, 1981.

12. Randle, J. W. Analysis of English 7 and 8 Essays. Unpublished manuscript, St. Edwards College, Austin, 1981.

13. Steffensen, M.S., Jogdeo, C., & Anderson, R. C. A cross-cultural perspective on reading comprehension (Tech. Rep. 97). Champaign, IL: Center for the Study of Reading, University of Illinois, July 1978.

References

Carpenter, P., & Just, M. Sentence comprehension: A psycholinguistic processing model of verification. *Psychological Review*, 1975, *82*, 45-73.

Clark, H. H., & Chase, W. C. On the process of comparing sentences against pictures. *Cognitive Psychology*, 1972, *3*, 472-517.

Daneman, M., & Carpenter, P. Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, 1980, *19*, 450-466.

Duran, R. P. Reading comprehension and the verbal deductive reasoning of bilinguals. In R. P. Duran (Ed.), *Latino language and communicative behavior*. Norwood, NJ: Ablex, 1981, 311-336.

Frederiksen, J., Warren, B., Gillote, H., & Weaver, P. The name of the game is literacy. *CCN*, May/June 1982, 23-27.

Hines, T. M. *The independence of language in bilingual memory*. Unpublished Ph.D. dissertation, University of Oregon, 1978.

Hunt, E., & MacLeod, C. M. The sentence-verification paradigm: A case study of two conflicting approaches to individual differences. *Intelligence*, 1978, *2*, 129-144.

Johnson-Laird, P., & Steedman, M. The psychology of syllogisms. *Cognitive Psychology*, 1978, *10*, 64-99.

Kintsch, W. Recognition memory in bilingual subjects. *Journal of Verbal Learning and Verbal Behavior*, 1970, *9*, 405-409.

Kintsch, W., & Kintsch, E. Interlingual interference and memory processes. *Journal of Verbal Learning and Verbal Behavior*, 1963, *2*, 291-300.

Kolers, P. A. Reading and talking bilingually. *American Journal of Psychology*, 1966a, *79*, 357-376.

Kolers, P. A. Interlingual facilitation of short-term memory. *Journal of Verbal Learning and Verbal Behavior*, 1966b, *5*, 314-319.

Lambert, W. E. Measurement of the linguistic dominance of bilinguals. *Journal of Abnormal and Social Psychology*, 1955, *50*, 197-200.

Lopez, M., & Young, R. K. The linguistic interdependence of bilinguals. *Journal of Experimental Psychology*, 1974, *102*, 981-983.

Lopez, M. Bilingual memory research: Implications for bilingual education. In J. L. Martinez, Jr. (Ed.), *Chicano Psychology*, New York: Academic Press, 1977, 127-140.

MacLeod, C. M., Hunt, E. B., & Mathews, N. N. Individual differences in the verification of sentence-picture relationships. *Journal of Verbal Learning and Verbal Behavior*, 1978, *17*, 493-507.

MacNamara, J. The effects of instruction in a weaker language. *Journal of Social Issues*, 1967, *23*, 121-135.

MacNamara, J., & Kellaghan, T. D. Reading in a second language. Undated manuscript cited in MacNamara, J., The effects of instruction in a weaker language. *Journal of Social Issues*, 1967, *23*, 121-135.

Marcos, L. R., & Trujillo, M. D. Culture, language and communicative behavior: The psychiatric examination of Spanish-Americans. In R. P. Duran (Ed.), *Latino language and communicative behavior*. Norwood, NJ: Ablex, 1981, 187-194.

McCormack, P. D. Bilingual linguistic memory: The independence-interdependence issue revisited. In P. A. Hornby (Ed.), *Bilingualism: psychological, social and educational implications*. New York: Academic Press, 1977, 57-66.

MacLeod, C. M. Bilingual episodic memory: Acquisition and forgetting. *Journal of Verbal Learning and Verbal Behavior*, 1976, *15*, 347-364.

Meyer, D. E., & Ruddy, M. G. Bilingual word-recognition: Organization and retrieval of alternative lexical codes. Paper delivered at the Eastern Psychological Association meeting, April 18-20, 1974.

Meyer, D. E., & Schvaneveldt, R. W. Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology*, 1971, *90*, 227-234.

Young, R. K., & Navar, M. I. Retroactive inhibition with bilinguals. *Journal of Experimental Psychology*, 1968, *77*, 109-115.

Young, R. K., & Saegert, J. Transfer with bilinguals. *Psychonomic Science*, 1966, *6*, 161-162.

Young, R. K., & Webber, A. Positive and negative transfer with bilinguals. *Journal of Verbal Learning and Verbal Behavior*, 1967, *6*, 874-877.

Chapter 3

Research Questions and Research Design

The major research questions in the present project can be divided into four areas. Figure 3-1 summarizes these areas, the tasks used to investigate an area and the central issue motivating research in each area. Each of the first three areas of research is related to important aspects of the problem solving model of bilingual behavior discussed in Chapter 2. In addition, the fourth area of research was an exploraton of the relationships in performance measures across reading proficiency, elementary cognitive tasks and logical reasoning tasks. A more detailed description of the research design and specific questions in each area of research is presented in this chapter.

Insert Figure 3-1 About Here

A. Reading and Language Proficiency of Subjects

As mentioned in the previous chapter, investigations of bilinguals' cognitive skills need to take into consideration global indicators of bilinguals' ability in the language of problem presentation. All of the logical reasoning and elementary and cognitive tasks investigated in this project required subjects to read material in Spanish and in English. Hence, assessment of the subjects' reading comprehension skill in Spanish and English was a primary goal of research and was necessary to interpret subject's performance on other tasks.

Reading comprehension proficiency was assessed by administration of parallel reading tests in each language. The instruments utilized were the Prueba de Lectura, Nivel 5 - Advanzado Forma Des and the Test of Reading, Level 5 - Advanced Form CE (Guidance Testing Associates, 1962). Each instrument yielded three part-scores and a total composite score of reading comprehension ability. Further details on these instruments and their administration are provided in the next chapter.

The Mexican American subjects in this study were expected to show greater reading proficiency in English than in Spanish because subjects would have been likely to receive most or all of their education prior to college in the English language. Previous survey research cited in Chapter 1 suggested that the subjects ought nonetheless to have measureable reading

Figure 3-1

Four Question Areas, Tasks, and Issues of Research

A. Reading and Language Proficiency Characteristics of Subjects

Issue: How did subjects vary in their knowledge of Spanish and English based on:

- o Advanced Reading Comprehension Test Performance
- o Background Questionnaire Responses

B. Elementary Cognitive Task Performance

Issue: How similar was subjects' performance in two languages on elementary cognitive tasks:

- o Word Recognition Task (Adapted from Meyer-Schvaneveldt, 1971)
- o Sentence Verification Task (Adapted from Hunt & MacLeod, 1978)
- o Reading Span Task (Adapted from Daneman & Carpenter, 1980)

C. Logical Reasoning Task Performance

Issue: How similar was subjects' performance in two languages on three logical reasoning tasks:

- o Syllogisms Task (Adapted from Johnson-Laird & Steedman, 1979)
- o Inference Test (Adapted from Ekstrom, French, & Harmon, 1976)
- o Logical Reasoning Test (Adapted from French, Ekstrom, & Price, 1963)

Issue: How similar was performance data on the Syllogism Task to performance data obtained by Johnson-Laird and Steedman?

Figure 3-1 (continued)

D. Relationships Between Syllogism Performance, Proficiency and Cognitive Task Performances

Issue: Was Syllogism performance significantly related to other measures of reading proficiency and to measures of cognitive task performance?

Issue: Were there any other noteworthy significant relationships among proficiency and cognitive tasks measures?

proficiency in Spanish. Accordingly, one important step in evaluating subjects' proficiency was to determine the range as well as the level of reading comprehension proficiency in each language.

A language and general background questionnaire was administered to subjects in order to gain information on language experiences and personal characteristics which would aid interpretation of reading comprehension test scores. The questionnaire which was utilized is described in the next chapter. Items on the questionnaire included attention to self-judgments by subjects of their preferred language in academic tasks and their previous exposure to Spanish and English.

Reading comprehension test scores in Spanish and English were hypothesized to bear a positive relationship to all elementary cognitive and cognitive reasoning tasks. This matter is discussed in more detail later in this chapter.

B. Elementary Cognitive Tasks

Three tasks adapted from previous studies in the cognitive research literature were selected for administration to subjects in both Spanish and English. The three tasks are a Word Recognition Task, a Sentence Verification Task, and a Reading Span Task. The Word Recognition Task provided a set of performance measures which were sensitive to subjects' ability to recognize the graphemic representation of common words in a language. From the perspective of the bilingual problem solving model discussed in the previous chapter, performance on the Word Recognition Task should be sensitive to bilinguals' efficiency in recognizing the meanings of words that serve as input in a complex verbal problem.

The Sentence Verification Task provided a set of performance measures sensitive to subjects' ability to make decisions about the accuracy of simple sentences they read. This task probed subjects' ability to formulate a complete thought based on a sentence and to enact a simple decision procedure to verify the truth or falsity of a sentence. Performance measures on the Sentence Verification Task stressed speed in deciding whether the meaning of a sentence agreed with information in a pictoral image.

The Reading Span Task provided performance measures of subjects' immediate memory for words occurring in a sequence of sentences. In terms of the bilingual problem solving model presented in the last chapter, performance on the Reading Span Task assessed cognitive processes important to problem representation and conceptual solution. Subjects' ability to interpret a verbal problem would seem to be positively related to their ability to retain information verbatim--at least long enough so that an accurate and precise conceptual interpretation of problem statements might be made prior to devising and enacting problem solving plans.

The main issue under investigation with regard to each task was whether subjects' performance was similar or different across Spanish and English versions of the task. In undertaking comparisons, patterns of performance which had emerged in monolingual studies of these tasks were used to guide interpretation of the results.

As described in the next chapter, all of the elementary cognitive tasks which have been mentioned were administered via a microcomputer system which included a video monitor and response keys. In order to utilize this microcomputer system, it was necessary to adapt the materials and procedures followed in administration of the original version Word Recognition Task and Reading Span Tasks. The Sentence Verification Task was based on a microcomputer version provided by Colin MacLeod and Earl Hunt, and hence, essentially the same version of this task was used in the present study.

The modified versions of the Word Recognition and Reading Span tasks were as close to the original experimental versions as possible. We did not expect these task modifications to produce differential effects on performance in the present study when compared with performance in previous studies. Each task and its specific research hypotheses in the present study will now be discussed. Details on the procedures and materials involved in tasks are discussed in the next chapter.

Word Recognition Task. Meyer and Schvaneveldt (1971) investigated monolinguals' speed in recognizing whether pairs of word-like stimuli were actually both words or not. In this task, subjects were presented with four trial types: a) two associated words; b) two unassociated words; c) one word and one nonword; and d) two nonwords. Subjects responded as quickly as possible by pressing a response key which signified either "both words" or "not both words". Speed in correctly responding in this task reflected how quickly subjects could recognize the graphemic code for legitimate versus non-legitimate words in English. Thus, the task assessed how efficient subjects were in reading individual words. Speed in responding correctly to related words versus to unrelated words was hypothesized to be sensitive to a "priming" of semantic memory effect. According to the hypothesis, recognition of a word is tied with recognition of its underlying conceptual meaning and this in turn makes related concepts and their word codes more accessible than otherwise. Subjects would thus be "primed" or ready to recognize a word related to the first word they recognized. The results of Meyer and Schvaneveldt showed that subjects were fastest at recognizing stimulus pairs that were actually both words and that subjects' response speed to words that were related (e.g., "doctor-nurse") was faster than to words which were unrelated ("doctor-chair"). Speed in accurately responding "not both words" to two nonwords was found to be faster than speed in making the same response to a word-nonword pair.

Mixed language versions of this task have been previously investigated (e.g., Pali, Note 4, Chapter 2). The present investigation did not intermix languages of presentation in administering the Word Recognition Task. The purpose of a "pure" language administration of the task in the present study was to provide baseline data on subjects' efficiency in recognizing the graphemic code of words in each language separately.

Consistent with previous results (Meyer & Schvaneveldt, 1971) it was hypothesized that:

- Regardless of language, subjects would be more rapid in recognizing pairs of words that were related to each other (e.g., doctor-nurse) than recognizing pairs of words that were unrelated (e.g., doctor-chair).
- Regardless of language, subjects would be slower at recognizing pairs of stimuli that contained one nonword or two nonwords, with speed of decision making being faster for the latter.

A strong correspondence in the relative speed to respond correctly to the four stimulus pair types across languages would lend evidence to the hypothesis that the same kinds of cognitive processes are involved in recognizing words and accessing semantic memory for Spanish words as for English words. It was hypothesized that speed in responding to stimuli in the Spanish version task would be slower than speed in responding to stimuli in the English version task. This expected difference in speed would be due to subjects' lower proficiency in Spanish and also possibly due to the longer letter and syllable length of common words in Spanish as opposed to common words in English.

Because the Spanish and English versions of the Word Recognition Task were administered twice on two separate days, it was possible to evaluate whether practice with the task affected performance. It was hypothesized that, regardless of whether or not speed of performance improved on the second day, the same ordinal relationship of speed in responding to various word stimuli types would be perserved for each language across the two days of task administration. Affirmation of this hypothesis would support the conclusion that the same underlying cognitive processes were being tapped by the Word Recognition Task across languages.

Sentence Verification Task. Hunt and MacLeod (1978) and MacLeod, Hunt and Mathews (1978) investigated monolingual subjects' speed in accurately deciding whether a simple affirmative or negative sentence was true of a pictorial image. Their work was based on a research paradigm devised by Clark and Chase (1972). Hunt, MacLeod, and Mathews were concerned with how performance under different task conditions was affected by the memory representation strategies subjects followed while working the task. In performing the task, subjects were first asked to read a sentence-like statement such as STAR ABOVE PLUS (affirmative form) or STAR NOT ABOVE PLUS (negative form). After reading a sentence, the sentence disappeared from view and subjects were shown a pictorial image such as $\overset{+}{*}$ or + to which they then responded "True" or "False", depending on its agreement with the original sentence. In the task there are thus four basic trial types, depending on the affirmative or negative form of a stimulus sentence and the form of a stimulus image, $\overset{+}{*}$ or +. Previous research by Clark and Chase (1972) found that subjects were faster at making correct "True" or "False" responses for affirmative sentences than for negative sentences. For affirmative sentences, a correct response "True" was found to be faster than a correct "False" response. In addition, research showed that a correct "False" response was faster for negative sentences than a correct "True" response. Carpenter and Just (1975) developed a detailed information processing model to account for the foregoing differences in response speed. This model was based on a description of the information processing transformations and decisions which subjects needed to make under different trial conditions. Hunt, MacLeod and Mathews found that the relative ordering of response times on the task could be influenced by subjects' use of an image versus propositional encoding strategy for sentences. Subjects with high visual ability were found to be slower at making correct "False" response to negative sentences than they were at making correct "True" responses to negative sentences. This effect was the opposite of what was predicted by the Carpenter and Just (1975) model.

A bilingual Spanish-English version of the Sentence Verification Task used by Hunt, MacLeod, and Mathews was adapted for use in the present study. The task was administered separately in Spanish and English. A new sentence type, "X next to Y" or "X not next to Y", was inserted into the task in order to discourage subjects from adopting a spatial imaging strategy. As in the Hunt, MacLeod, and Mathews task, the words STAR and PLUS were used as the subject and object of sentence forms and the predicate of sentence-like forms could be "Above" or "Below", or "Next to". "Not" could also be placed before the predicate term as in "STAR NOT NEXT TO PLUS".

It was hypothesized that bilingual subjects in the current study would perform in each of their languages in accordance with the Clark and Chase findings outlined previously and in accordance with the Carpenter and Just model. It was also hypothesized that correct response times would not differ across Spanish and English trials of the same types as investigated by previous researchers. The latter hypothesis was based on the notion that subjects memory representation for the meaning of a stimulus sentence was in a propositional memory code and not in a language code after a subject had read a sentence. Thus, once a pictorial image was presented, subjects' decision time would no longer be based on manipulating a language code. Regardless of whether Spanish or English was used as the input medium for sentences, it was hypothesized that the memory code representation for the meaning of a sentence was the same.

If the results of the present study deviated from the foregoing hypothesis, then this would provide evidence that the language of input for sentences somehow was related to establishment or manipulation of the memory code for sentence meaning in the task. If differences in speed of processing across languages were to occur, it was hypothesized that speed of responding would be faster in English than in Spanish, since subjects had stronger proficiency in English.

Reading Span Task. Daneman and Carpenter (1980) found that short term memory for individual words occurring in a sequence of written or orally presented sentences was significantly associated with monolingual subjects' verbal aptitude test scores. In the written stimulus version of the task, known as Reading Span, subjects read sentences presented sequentially on cards, aloud. Sentences were 13 to 16 words in length and the number of sentences varied from two to six sentences. Sentences were presented in blocks of three sets. The first block involved 3 sets of two sentences each; the second block involved 3 sets of three sentences, and so on, up through the final block which involved 3 sets with six sentences in each set. After reading each sentence set, subjects were asked to recall the last words of each sentence in the order in which they had occurred. Subjects' performance was measured by a level score which was equal to number of sentences in the block with the most sentences for which subjects recalled at least two of three sets of last words without error. The level scores could vary from two to six. Subjects' Reading Span level score was found to correlate .59 with Verbal SAT scores, .72 with a test for facts presented in a reading passage, and .90 with a test of ability to identify the referents of pronouns in a reading passage. Daneman and Carpenter (1980) concluded that their Reading Span test was an excellent measure of subjects' verbal memory capacity and that this measure would be highly sensitive to individual differences.

In the present study a computer-delivered version of the Reading Span task was administered to bilingual subjects separately in Spanish and English. It was hypothesized that subjects' score on this task would be higher in English than in Spanish, because of subjects' stronger proficiency in English. It was also hypothesized that subjects' performance in each language would be significantly related to their reading comprehension test scores in each language.

Performance on the Reading Span task ought to reflect subjects' ability to hold in working memory the verbal code of sentences involved in the statement of a problem. Reading Span aptitude would thus influence problem representation and conceptual interpretation of problems based on the verbal statement of a problem. Bilinguals' Reading Span scores in each language thus might be used to assess the degree of disadvantage that bilinguals face in working verbal problems in their less familiar language as opposed to their more familiar language.

C. Logical Reasoning Tasks

Bilinguals' performance on three logical reasoning tasks in Spanish and English were investigated. The task of most interest was a Syllogisms Task adapted from the work of Johnson-Laird and Steedman (1978). In their experiment, Johnson-Laird and Steedman found that monolingual subjects' propensity to generate valid conclusions of a particular type to pairs of syllogism premises was strongly influenced by the order and placement of predicate terms within syllogism premises. The present study replicated Johnson-Laird and Steedman's experiment using a microcomputer as the means for presenting syllogism premise pairs to subjects. An important goal was to investigate whether subjects performed similarly or differently on Spanish and English versions of the task. The syllogisms task was valuable for the present study because it allowed for analysis of bilinguals' problem solving in each language in a qualitatively rich way anchored to previous psycholinguistic research on syllogistic reasoning.

In addition to the Syllogisms Task, bilingual subjects were administered two pencil and paper tests of reasoning known as the Inference Test and the Logical Reasoning Test. Both tests had been adapted for bilingual administration and performance on these tests had been found to intercorrelate significantly (Duran, 1979). The two tests in question were expected to also correlate with performance on the Syllogisms Task. The next chapter describes these instruments in more detail. Attention will now be given to the specific research issues and questions posed by the Syllogisms Task since this task is of central interest.

Syllogisms Task. The general theoretical perspective on the representation and solution of syllogisms followed in the present project is attributable in large part to Johnson-Laird and Steedman (1978). According to Johnson-Laird and Steedman, the solution of syllogisms does not typically involve use of some special mental calculus coincident with formal representations of deductive systems. Instead Johnson-Laird and Steedman suggest that subjects follow some general heuristics for representing class membership relations given in the syllogism premises and then apply other heuristics in generating, verifying, and falsifying tentative conclusions.

In an investigation of syllogistic inference in college students, Johnson-Laird and Steedman (1978) found that the "figure" of the syllogism had a strong effect on the accuracy of performance and on the form of the conclusion drawn. The "figure" of syllogism refers to the location in the premises of the middle term common to both premises and absent from the conclusion. Traditionally, the four figures for syllogistic premises are:

First	Second	Third	Fourth
A B	A B	B A	B A
B C	C B	B C	C B

Johnson-Laird and Steedman reported a bias toward A--C conclusions for the first figure and toward C-A conclusions for fourth figure. Furthermore, this figural bias affected the ease with which a syllogism could be solved. Syllogisms with valid conclusions compatible with the figure of the premises were relatively easy while those with valid conclusions opposite in form to the syllogism's figure were very difficult.

To account for these results Johnson-Laird and Steedman proposed an analogical model of syllogistic reasoning. According to this model there are four steps in solving syllogisms:

1) formulating a mental representation of the premises

2) combining the representations of the premises

3) generating a tentative conclusion

4) testing the tentative conclusion and modifying it if necessary

In the first step, subjects formulate a mental representation of the premises which preserves the relationships among the terms. It is hypothesized that subjects represent classes by thinking of an arbitrary number of exemplars. The following schemata are used by Johnson-Laird and Steedman to illustrate the form such representations might take:

$$\begin{array}{ccccccccccccc}
\multicolumn{3}{c}{\text{All A are B}} & & \multicolumn{2}{c}{\text{Some A are B}} & & \multicolumn{2}{c}{\text{No A are B}} & & \multicolumn{2}{c}{\text{Some A are not B}} \\
a & a & & & a & (a) & & a & a & & a & (a) \\
\downarrow & & & & \downarrow & & & \perp & \perp & & \perp & \downarrow \\
b & b & (b) & & b & (b) & & b & b & & y & y
\end{array}$$

Each vertical sequence shows an example of a relationship that could occur between a member of a set A and a member of a set B. Lower case letters designate members of the set designated by upper case letters. A vertical "↓ " as in $\begin{matrix}a\\ \downarrow\\ b\end{matrix}$ means "an 'a' is 'b' . A "$\perp$" as in $\begin{matrix}a\\ \perp\\ b\end{matrix}$ signifies that "there is ''a' that is not a 'b' ". The terms in parentheses represent optional elements in the premises. For example, if "all A are B" there may be some $\underline{b}$'s that are not a. Absence of an ↓ or $\perp$ between examples indicates failure to identify a definite relationship between examples.

The representations of the first and second premise are combined in the second step. It is assumed that there is a bias toward linking the end terms via the common middle term. Thus the premises "All A are B" and "Some B are C" are combined as follows:

$$\begin{array}{ccc}
a & a & \\
\downarrow & & \\
b & b & (b) \\
\downarrow & \downarrow & \\
c & (c) &
\end{array}$$

The third step is to formulate a possible conclusion on the basis of the representation. Here the nature of the paths linking the end items is the critical factor. The presence of at least one negative path leads to the conclusion "Some A are not C" and the presence of only negative paths lead to the conclusion "No A are C." Otherwise, the presence of at least one positive path results in the conclusion "Some A are C" while if the only positive paths are present, the conclusion is "All A are C."

It is at this stage that figural effects have an influence on the form of the conclusion. If the paths connecting the end elements are unidirectional, a figural bias occurs. Otherwise no bias is expected. The first example below illustrates a syllogism which leads to the biased conclusion "Some A are C" rather than the equally valid conclusion. "Some C are A" while the second example illustrates an unbiased syllogism for which these two valid converse conclusions are drawn with equal facility.

1)	Some A are B	a	(a)	
		↓		
	All B are C	b	(b)	
		↓	↓	
		c	c	(c)
	(type of path)	(+)	(?)	
2)	All B are A	a	a	
		↑	↑	
	Some B are C	b	(b)	
		↓		
		c		
	(type of path)	(+)	(?)	

The fourth and final step in solving the syllogism is testing the tentative conclusion generated in step 3. At this stage the subject tests the conclusion by trying to falsify the paths between end items without creating contradictions of the original premises. If the initial conclusion can be falsified, the subject will have to modify and retest the conclusion appropriately.

It should be noted that in modeling this theory in the form of a computer program, Johnson-Laird and Steedman found that a few simplifications during test phase facilitated the solution to some type of syllogisms. Interestingly, the simplifications or "short cuts" corresponded to three traditional laws of logic:

1) no conclusion can be drawn from two negative premises

2) the middle term must be distributed at least once in a valid syllogism

3) no term may be distributed in the conclusion that is not distributed in the premises.

An important implication of this theory is that subjects may be quite good at generating conclusions on a heuristic basis but less efficient at testing these tentative conclusions. Thus, there is a basis for predicting the kind of erroneous conclusions that may be expected for a particular syllogism as well as the relative difficulty of different syllogisms. The relative difficulty of different syllogisms is related to the amount of testing that must be done to falsify or verify a conclusion and to the type of relationship between figure of the premises and the form of the conclusion. This model of syllogistic reasoning is valuable because it has done fairly well in accounting for empirical finding on common forms of errors in solving syllogisms that potentially reflect (a) parsimony in cognitive effort, (b) influences of semantic content and order of information in syllogisms, and (c) number of alternative premise or conclusion interpretations which must be considered in solving syllogisms.

In the present study both Spanish and English syllogism problems were presented to the bilingual subjects. It was hypothesized that subjects' performance in English would resemble the performance of subjects in the Johnson-Laird and Steedman research. That is, subjects would show a response bias for A-C conclusions when presented a premise with the figure A-B and B-C. Similarly, subjects were hypothesized to show a response bias for C-A conclusions when presented premises with the figure B-A and C-B. It was also hypothesized that subjects would be more accurate in drawing conclusions for syllogisms where the order of mention of predicates and form of the conclusion resembled the statement of premises.

Performance of subjects in Spanish was hypothesized to be less accurate and to show more frequent response bias than in English. There were no strong grounds for this hypothesis apart from the conjecture that since subjects were more familiar with English than Spanish, that they would subsequently be able to maintain and operate on more elaborate and thorough representations of syllogism problems in their stronger language. The advantage in accuracy of English language performance was hypothesized to be more evident for syllogisms which required intermediate steps in arriving at a conlcusion and which thereby might require extensive testing of the validity of a candidate conclusion.

D. Relationships Among Tasks

The investigation of cognitive and reasoning tasks in the present project was not based on a strong information processing model of how performance variables would be associated across tasks. There were expectations, however, that there would be significant relationships between some Syllogism Task performance variables and other variables. First, it was hypothesized that overall accuracy of performance on the Syllogisms task in a language would be significantly related to pencil and paper reasoning test scores and reading comprehension test scores. These relationships were expected to be strongest among measures obtained in English than in Spanish, consistent with the previous findings of Duran (1981).

A significant statistical relationship was hypothesized to exist for each language between overall accuracy of Syllogism Task performance and performance measures on the Word Recognition, Sentence Verification, and Reading Span Tasks. All of the latter tasks involved skill in being accurate and efficient in recognizing and processing meaning of language input in simple problem solving tasks and in making simple problem solving decisions based on the interpretation of input language.

Solution of Syllogism Task problems, on the surface would appear to involve skills central to each of the elementary cognitive tasks cited. For example, reading of syllogism premises would require: recognizing the individual words of sentences--a skill basic to the Word Recognition Task; remembering the words of syllogism sentences long enough to interpret the meaning of a sentence--a skill reflected in the Reading Span Task; and ability to make "true" or "false" decisions about the meaning of sentences--a skill reflected in the Sentence Verification Task. Thus there were some grounds for hypothesizing that Syllogisms Task performance would be related to other cognitive measures, but there was no detailed information processing or cognitive component processing model which was available to link performances together across tasks. Construction of an appropriate model and an appropriate research procedure would involve a much more thorough and elaborate analysis of Syllogisms Task performance, along the lines of research procedures as suggested by Sternberg (1983), for example. Investigation of relationships between Syllogisms Task performance and latency, accuracy, and response type measures for other elementary cognitive tasks was an exploratory process in the current project.

Investigation of relationships among elementary cognitive task performance measures across tasks and of these measures with reading comprehension test scores was exploratory. It was hypothesized that measures of performance on the Word Recognition Task and the Reading Span Task would be significantly related to reading comprehension test scores in the same language as tasks. This association was expected to be more pronounced for Spanish than for English since subjects' skill in Spanish was more variable and critical to task performance given the language proficiency profile of subjects. Performance on the Sentence Verification Task was not expected to correlate significantly with reading comprehension test scores because decision making time in the Sentence Verification task was independent of time required to read sentences describing figural images.

References

Carpenter, P., & Just, M. Sentence comprehension: A psycholinguistic processing model of verification. Psychological Review, 1975, 82, 45-73.

Clark, H. H., & Chase, W. C. On the process of comparing sentences against pictures. Cognitive Psychology, 1972, 3, 472-517.

Daneman, M., & Carpenter, P. Individual differences in working memory and reading. Journal of Verbal Learning and Verbal Behavior, 1980, 19, 450-466.

Duran, R. P. Reading comprehension and the verbal deductive reasoning of bilinguals. In R. P. Duran (Ed.), Latino language and communicative behavior. Norwood, NJ: Ablex, 1981, 311-336.

Ekstrom, R. B., French, J. W., & Harman, H. H. Manual for kit of factor-referenced cognitive tests. Princeton, NJ: Educational Testing Service, 1976.

French, J. W., Ekstrom, R. B., & Price, L. A. Manual for kit of reference tests for cognitive factors. Princeton, NJ: Educational Testing Service, 1963.

Guidance Testing Associates. Prueba De Lectura, Nivel 5--Advanzado-Forma DES, 1962.

Guidance Testing Associates. Test of Reading, Level 5--Advanced Form CE, 1962.

Hunt, E., & MacLeod, C. M. The sentence-verification paradigm: A case study of two conflicting approaches to individual differences. Intelligence, 1978, 2, 129-144.

Johnson-Laird, P. & Steedman, M. The psychology of syllogisms. Cognitive Psychology, 1978, 10, 64-99.

MacLeod, C. M., Hunt, E. B., & Mathews, N. N. Individual differences in the verification of sentence-picture relationships. Journal of Verbal Learning and Verbal Behavior, 1978, 17, 493-507.

Chapter 4

Method

Apparatus

A microcomputer was used to present stimuli and to record responses for four of the tasks. The four tasks involved were the Word Recognition Task, the Sentence Verification Task, the Reading Span Task and the Syllogisms Task. An Apple II, Plus computer with 48K RAM, two disk drives, a Leedex 12" monitor (model Video 100), a Mountain Hardware millesecond clock (model MHP-X003) and Pro-Paddle game response switches were used. Lower case characters and Spanish language punctuation marks were programmed using the Applesoft Tool Kit (Apple, 1980). Subjects' response data were stored on 5 1/4 inch Inmac Plus diskettes for transfer to a main frame computer used for data analyses.

Subjects

Fifty-seven Mexican American college undergraduates served as subjects in the study during the period Fall 1981 through Spring 1983. Subjects were recruited by the two project research assistants who were undergraduate students at Princeton University--the principal sampling site for subjects. Fifty-one out of the 57 subjects verified their attendance at Princeton in their responses to a background questionnaire. Four of the remaining six subjects did not indicate their current school; it is likely that these subjects also attended Princeton. Of the 53 subjects who answered a question on gender, 49.1 percent indicated that they were males. Subjects had averaged 2.33 years of University study. The average age of subjects was 19.9 years, with the age ranging from 17 to 26 years.

Thirty-four subjects were born in either California or Texas and another eight were born in other states. Nine were born in Mexico and one in Ecuador. Almost 60 percent of subjects had fathers who were born in the U.S., while about 51 percent indicated their mothers had been born in the U.S.

Schedule

A series of seven cognitive tasks were presented as either paper and pencil tests or on an Apple Computer. Both English and Spanish versions of the tasks were presented to each subject. In addition, subjects completed a background questionnaire on their own time.

Participation in the study was broken into three sessions over three separate days. Sessions 1 and 2 took about 2 1/2 hours each while Session 3 was approximately 3 hours and 20 minutes long. The sessions were conducted at the subjects' convenience and the intersession intervals varied among subjects. The total participation time of the subjects was about 8 hours and 20 minutes. Subjects were payed $60.00 for their participation in the study.

The tasks included paper and pencil tests of inferential reasoning, logical reasoning, and reading comprehension. The four tasks which were presented via the computer included the Word Recognition Task, the Syllogism Task, the Reading Span Task and the Sentence Verification Task. The testing schedule, presented in Table 4-1, was the same for all subjects. The English version of a particular task was always presented before the Spanish version. This was done to insure that subjects thoroughly understood the instructions for tasks prior to encountering the Spanish version. It was also expectated that practice effects would help to reduce differences in Spanish versus English performance due to the greater familiarity of English for most of the subjects. Counterbalancing of language of task presentation would have been preferable, but such a maneuver could have confounded subjects' familiarity with task instructions with their performance in Spanish versus in English.

Insert Table 4-1 About Here

Instruments

Background Questionnaire. The purpose of the questionnaire was to obtain information about the subjects personal and educational background as a bilingual. The majority of the questions were about the subject's early language experience at home and in schools and his/her comparative facility in both languages. Other questions concerned the student's present educational level, furture educational and career plans, and the occupation of his/her parents. A copy of the questionnaire is presented in Appendix A.

Reading Comprehension Tests. Subjects were administered the Prueba de Lectura, Nivel 5, Advanzado Forma DEs and the Test of Reading, Level 5, Advanced Form CE (Guidance Testing Associates, 1962). Tests were administered in each language within a 60-minute period; the total time spent working on the three test parts was 41 minutes. Part scores yielded by the test included Vocabulary, Speed, and Level. A composite

Table 4-1

Testing Schedule

Day 1

	Time	
Word Recognition, English, Day 1		20
Word Recognition, Spanish, Day 1		20
Inference Test, English		10
Inference Test, Spanish		10
Syllogisms, English, Day 1		45
Syllogisms, Spanish, Day 1		45
	2:30 hrs.	150

Day 2

	Time	
Word Recognition, English, Day 2		20
Word Recognition, Spanish, Day 2		20
Syllogisms, English, Day 2		45
Syllogisms, Spanish, Day 2		45
Logical Reasoning, English		10
Logical Reasoning, Spanish		10
	2:30 hrs.	150

Day 3

	Time	
Reading Span, English		20
Reading Span, Spanish		20
Reading Test, English		60
Reading Test, Spanish		60
Sentence Verification, English		20
Sentence Verification, Spanish		20
	3:20 hrs.	200

Total 8:20 hrs.

Background questionnaire completed on subjects' own time total score was also computed. In a previous study Duran (1981) found that the reading comprehension tests in question were of sufficient difficulty for college students and that the test subscores manifested internal reliability coefficients that were at or above .88 Alpha.

Inference Test. Spanish and English versions of this instrument were developed earlier by Duran (1979) and were adapted from the Inference Test investigated by Ekstrom, French, and Harman (1976). A copy of the cover page of Spanish and English instruments is presented in Appendix A. The length of Spanish and English versions were 10 items, one-half the length of the original English language instrument. The Spanish and English versions of this test contained different items. Previous research by Duran (1979) found that the Spanish version of the test manifested an Alpha reliability coefficient of .51, while the English version of the test manifested an Alpha reliability coefficient of .70.

Items consisted of short, two or three sentence paragraphs followed by a set of five conclusions which were alleged to follow from a passage. Subjects were required to select the single correct conclusion for each set. Responses were entered by circling the letter of correct responses as printed in test booklets. Subjects were allowed 10 minutes to complete this test in either language.

Logical Reasoning Test. Spanish and English versions of this instrument had been previously developed by Duran (1979) and were adapted from the Logical Reasoning Test studied by French, Ekstrom, and Price (1963). A copy of the cover pages of the Spanish and English instruments is presented in Appendix A. The length of the Spanish and English versions of this test was 20 items, one-half the length of the original English language instruments. The Spanish and English versions of this test contained different items. Duran (1979) reported that the Spanish version of the test manifested an Alpha reliability coefficient of .70, while the English version of the test manifested an Alpha reliability coefficient of .83.

Items consisted of pairs of syllogism premises. For each item subjects were required to pick the one correct conclusion which followed from premise pairs based on four multiple choice alternatives. Answers were recorded on test booklets by circling the letter of the selected conclusion for each syllogism item. Subjects were allowed 10 minutes to complete this test in each language.

Cognitive Task Procedures

Word Recognition Task. The procedures used in designing and administering this task were adapted from Meyer and Schvaneveldt

(1971). Subjects were administered the Word Recognition Task twice in each language over a two-day period. The task was administered via an Apple II microcomputer system utilizing a video monitor to visually present stimuli and game paddle switches to record subjects' responses.

The stimuli were pairs of letter strings presented in the center of the video monitor screen, one above the other. Each letter string was from three to eight letters in length. Spanish letter strings were slightly longer than English strings on the average. Exemplary stimulus materials in English were provided by David Meyer for possible use in this study. These materials were utilized. Spanish language materials, however, had to be created.

Individual letter strings were either a word or a nonword. All words were common vocabulary terms encountered in either Spanish or English. Spanish words averaged half a syllable longer than English words. English and Spanish nonwords resembled bona fide words in each language. Nonword stimuli were created by applying a set of one, two, or three letter transformation rules to bona fide words.

Spanish word and nonword stimuli were based on a corpus of common Spanish words which was especially developed for the project. The corpus was accumulated by drawing on vocabulary materials used in teaching Spanish as a foreign language. The corpus consisted only of words which had no direct semantic equivalent among the English words utilized in the study.

There were four types of stimulus pairs. One type consisted of associated words, e.g., doctor-nurse, while a second type consisted of unassociated words, e.g., chair-horse. A third type of stimulus consisted of two nonwords, e.g., tolf-lun. A fourth type of stimulus consisted of a word paired with a nonword, e.g., prarp-carrot. In the case of the latter stimuli, half of the letter strings which subjects saw on top were words, while for the remaining half of stimuli nonwords were on top.

An experimental block of Word Recognition Task trials in a language consisted of 96 stimulus pairs of word strings. Twenty-four of these pairs were associated words and 24 pairs were unassociated words. There were 16 pairs of nonwords and 32 pairs of words with nonword pairs; 16 of these 32 pairs had the word string above the nonword string. The computer program used to present this task randomly selected stimulus pairs for presentation.

Individual trials began with a "+" appearing in the center of the video monitor screen. Subjects pressed a response key to initiate presentation of a pair of letter strings. Letter strings appeared one-half second after a key press. Subjects responded by pressing one of two game paddle response buttons designating either "Both words" or "Not both words". Immediately after responding the feedback "CORRECT" or "INCORRECT" appeared on the screen. After a one second delay a "+" reappeared in the center of the screen to commence the next trial. The subjects' response and reaction time in milliseconds on each trial was stored in computer memory. At the conclusion of a block of trials, this response information was written on the subject diskette.

A practice block of 48 trials was administered prior to the experimental block in each language. The purpose of the practice block of trials was to remove the influence of a warm-up effect from the data to be analyzed.

Sentence Verification. In the sentence verification task (Clark & Chase, 1972) subjects had to judge if a simple sentence such as PLUS ABOVE STAR was a true description of a geometric stimulus such as + or $\overset{+}{*}$. The subjects' speed in making this judgment is thought to measure how efficient subjects are in elementary problem solving.

The total stimulus set consisted of 32 sentence-picture pairs. Sixteen of these pairs were the same as the stimuli traditionally used in this paradigm. These were all possible sentence-picture pairs resulting from the factorial combination of the four binary dimensions of preposition (above or below), word order (Star-plus or plus-star), affirmative-negative and picture (+ or $\overset{+}{*}$). A second group of stimuli was formed using the prepositional phrase "next to" in the sentences and varying the dimensions of word order, affirmative-negative and picture (+ or $\overset{+}{*}$ or * + or + *). Both English and Spanish sets of stimuli were generated.

The task was presented on the computer. A trial began with the appearance of a sentence on the TV screen. After the subjects had read and understood the sentence, they pressed either of the two hand-held response buttons and a picture appeared in the center of the screen. The subjects indicated a sentence-picture match (true) by pressing the response button in their right hand, a mismatch (false) by pressing the button in their left hand. Feedback (correct or incorrect) appeared on the screen for one second after the subject responded. Subjects were instructed to be totally accurate and to work as quickly as possible.

Practice blocks of 32 trials were given prior to the experimental block for both the English and the Spanish version of the task. A subject had to meet a criterion of 28 right in the practice block before the experimental block was administered. The presentation order of the stimulus pairs was randomized within each block and between subjects.

The subjects' responses and two reaction times (i) reading time, from the onset of the stimulus display to the subjects first key press, and (ii) response time, from picture onset to the subjects true or false response, were automatically recorded.

Reading Span. This task, adapted from the work of Daneman and Carpenter (1980), was designed to assess an individual's working-memory capacity. The task was administered in English and Spanish versions. Subjects were required to read aloud a series of sentences, presented successively on the video screen and then write down the last word from each sentence. Sentences varied in length from 8 to 13 words. The sentences used in the present project were selected from popular publications in English and Spanish. Only content words were allowed to appear as last words in sentences and sentences which were likely to stimulate unusual emotive reactions were avoided. The stimulus sentences in English and Spanish which were used are presented in Appendix B.

Sentences were presented in sets of two, three, four, five and six sentences. The various sizes represented different levels of task difficulty and three sets of sentences were given at each level. Set sizes were presented in ascending order. In addition, three sets of two sentences were initially presented as practice trials. Presentation order for sentences was randomized by the Apple microcomputer for each subject.

Subjects initiated the presentation of each sentence by pressing a hand-held response key. They were instructed to read the sentence aloud and then to immediately press the button for the next sentence. At the end of the series of sentences, "write" appeared on the screen. Subjects were instructed to write down the last word in each sentence in the same order in which the sentences has appeared. A special answer form was used for this purpose.

For each set of sentences, responses were scored in terms of number of correct words in the right order, number of correct words in wrong order and total number of words correctly reported. In addition, each subject received a reading span score which was the largest set size at which the subject was totally correct for two out of three sets.

Syllogisms. The syllogism task was based on the work of Johnson-Laird and Steedman (1978) and then procedures were closely followed. Subjects were presented with two syllogistic premises from which they had to draw a conclusion.

Four sets of 64 syllogisms were created, two sets in English and two in Spanish. The syllogisms were generated by varying the mood of the premises. Traditionally the four moods of a premise are as follows:

1) A- Universal affirmative (All A are B)
2) I- Particular affirmative (Some A are B)
3) E- Universal negative (No A are B)
4) O- Particular negative (Some A are not B).

The syllogisms also varied in figure, i.e., the location in the premises of the subject and predicate of the conclusion and of the middle term common to both premises which is absent from the conclusion. The traditional four figures in logic are:

First	Second	Third	Fourth
A-B	A B	B A	B A
B-C	C B	B C	C B
A-C	A-C	A-C	A-C

Sixty-four types of syllogisms were thus created by factorally combining the moods of the first and second premise (4 x 4) and the figure (4) of the syllogism. Each type of syllogism was presented with sensible linguistic content. For example, the two premise forms "All x are y" and "All y are z" might have been realized as "All teachers are educators" and "All educators are reasonable". A list of the four sets of syllogisms used as stimuli in each language are presented in Appendix C. Due to an error, four of the syllogisms for the first figure administered on Day 2 were incorrectly formed. The responses to these syllogisms were excluded from the analysis.

The syllogisms were presented on the video monitor.and presentation order was randomized for each subject. Subjects were instructed that they would see two sentences and that they were to draw valid conclusions which combined information from the two statements. They were also instructed that they should cast their conclusions in one of the following forms:

1) All ___ are ___
2) Some ___ are ___
3) No ___ are ___
4) Some ___ are not ___
5) No valid conclusions

The subjects initiated the presentation of the sentences by pressing a hand-held button. They then read the two premises which were presented simultaneously, one above the other. After the subjects had formed a conclusion, they pressed a button to turn off the display and told their conclusion to the experimenter who wrote it down. A card with the desired answer forms was placed on the computer keyboard for easy reference. However, if the subject's response did not conform, it was accepted and subsequently scored as a deviate response.

The conclusions generated by subjects were coded by hand for form and accuracy. The 12 response categories used for coding were:

1) All A are C
2) All A are not C
3) Some A are C
4) Some A are not C
5) No A are C
6) All C are A
7) All C are not A
8) Some C are A
9) Some C are not A
10) No C are A
11) No conclusion
12) Another answer

In addition, the reading time for each syllogism, which had been automatically recorded, was considered as a measure of processing time.

References

Apple Computer, Inc. Applesoft Tool Kit. Cupertino, CA: 1980.

Clark, H. H., & Chase, W. C. On the process of comparing sentences against pictures. Cognitive Psychology, 1972, 3, 472-517.

Daneman, M., & Carpenter, P. Individual differences in working memory and reading. Journal of Verbal Learning and Verbal Behavior, 19, 450-466.

Duran, R. P. Reading comprehension and the verbal deductive reasoning of bilinguals. In R. P. Duran (Ed.), Latino language and communicative behavior. Norwood, NJ: Ablex, 1981, 311-3.

Duran, R. P. Logical reasoning skills of Puerto Rican bilinguals. Final Report to the National Institute of Education. Princeton, NJ: Educational Testing Service, 1979.

Ekstrom, R. B., French, J. W., & Harman, H. H. Manual for kit of factor-referenced cognitive tests. Princeton, NJ: Educational Testing Service, 1976.

French, J. W., Ekstrom, R. B., & Price, L. A. Manual for kit of reference tests for cognitive factors. Princeton, NJ: Educational Testing Service, 1963.

Guidance Testing Associates. Peueba de Lectura, Nivel 5--Advanzado-Forma DES, 1962.

Guidance Testing Associates. Test of Reading, Level 5--Advanced Form CE, 1962.

Johnson-Laird, P. & Steedman, M. The psychology of syllogisms. Cognitive Psychology, 1978, 10, 64-99.

Meyer, D. E., & Schvaneveldt, R. W. Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. Journal of Experimental Psychology, 1971, 90, 227-234.

Chapter 5

Results

The results will be discussed with respect to the four areas of research described in Chapter 3. These include: a) reading and language proficiency of subjects; b) performance on elementary cognitive tasks; c) performance on logical reasoning tasks; and d) relationships among performance in the first three areas.

A. Reading and Language Proficiency of Subjects

Performance on the Spanish and English version of the advanced reading comprehension test is compared in Table 5.1. T-tests on the correlated observations indicated subjects performed better in English than in Spanish on all three subtests (vocabulary, reading speed, comprehension level) as well as on the overall test.

Insert Table 5.1 About Here

The data support the hypothesis that subjects were better readers of English than of Spanish. The magnitude of the advantage of English over Spanish reading skill is around 1.5 standard deviation units for each reading test subscore and the total reading test score. Performance on the Spanish and English versions of the test was strongly correlated (see Table 5.1). Thus, there was a good deal of individual consistency in performance across the two languages. The substantial correlation in reading test scores across languages supports the notion that reading in either Spanish or English draws on many of the same skills in either language. Being skilled in reading English is related to being a good reader in Spanish--this despite the fact that subjects overall show more skill in reading English than in reading Spanish.

Data from a background questionnaire completed by subjects indicated that subjects judged themselves as far more proficient in English than in Spanish. Between 75 and 80 percent of the subjects said that they understood spoken English better than spoken Spanish and that they spoke English better than Spanish. Ninety percent of the subjects indicated that they could write better in English than in Spanish and all but 6 subjects indicated that they could read English better than Spanish.

These data support the hypothesis that subjects were more proficient in English than in Spanish. Furthermore, reading

Table 5.1

Comparison of Mean Scores on the Reading Comprehension Tests in English and in Spanish

	Language		Statistical tests[a]	
Test	English	Spanish	T-tests	Correlations
Vocabulary				
Mean	38.70	28.54	$t(55) = 11.31$	$r(55) = .55$
SD	6.07	7.79		
Speed				
Mean	19.63	9.95	$t(55) = 10.57$	$r(55) = .41$
SD	6.59	6.04		
Level				
Mean	36.68	24.07	$t(55) = 11.57$	$r(55) = .54$
SD	7.08	9.39		
Total				
Mean	94.93	62.77	$t(55) = 15.37$	$r(55) = .66$
SD	15.99	20.67		

[a] All $p<.001$, one-tailed.

proficiency was correlated across languages. Subjects who showed greater proficiency in English tended also to show greater proficiency in Spanish.

B. Elementary Cognitive Tasks

The elementary cognitive tasks include the Word Recognition Task, the Sentence Verification Task and the Reading Span Task.

Word Recognition Task. In this task subjects had to decide whether or not pairs of word-like stimuli were actually words. The four types of stimulus pairs included: a) two associated words; b) two unassociated words; c) one word and one nonword; and d) two nonwords. As discussed in Chapter 3, it was expected that associated word pairs would be processed more rapidly than unassociated word pairs and that processing would be slower for stimulus pairs that included one or two nonwords with the word-nonword pair requiring the longest processing time.

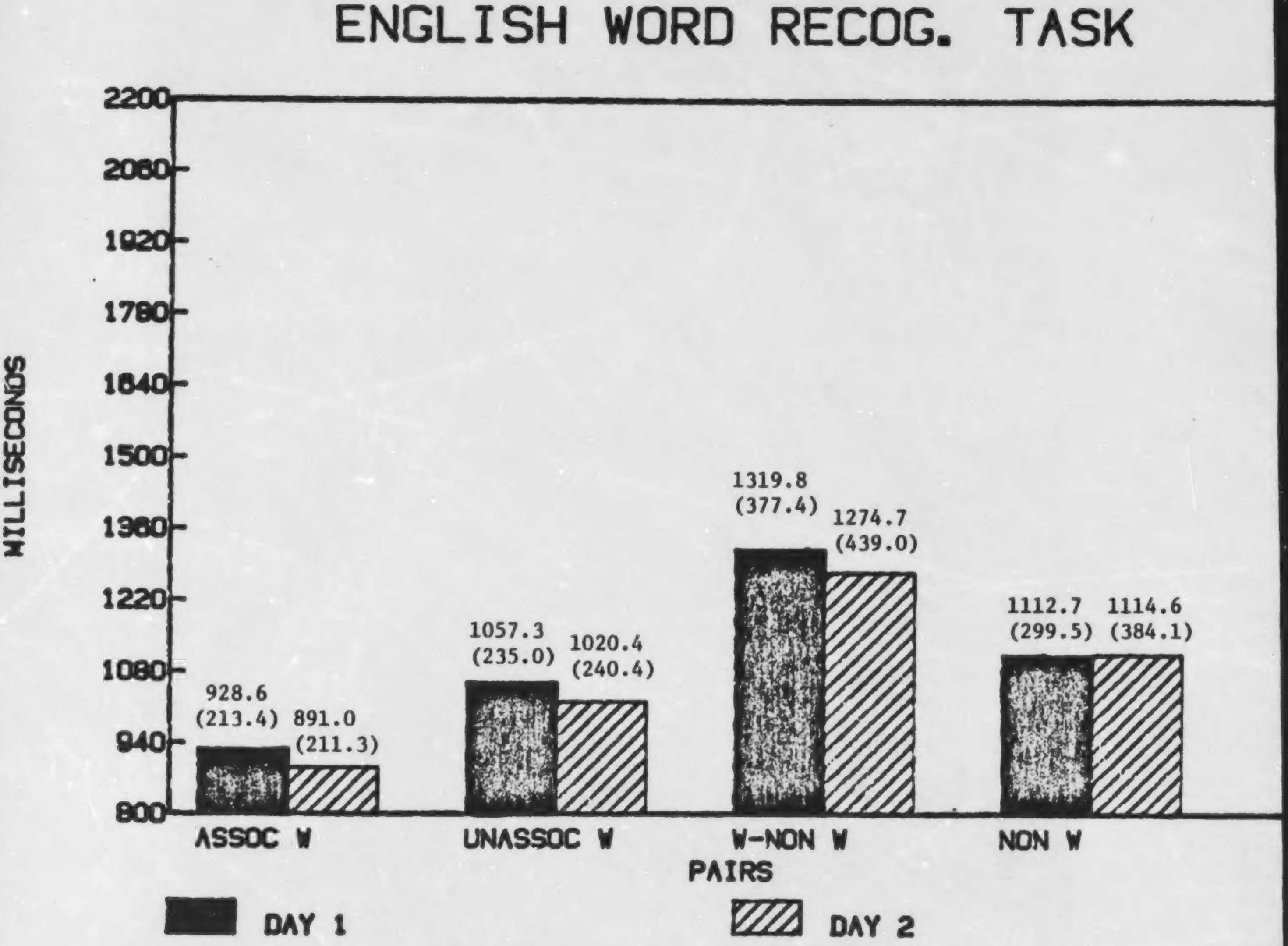
Individual mean reaction times to process the four types of word pairs were analyzed separately for English and Spanish in two Day (2) X Stimulus (4) multivariate analyses of variance with repeated measures on both factors. The mean reaction times for the four types of word pairs on Day 1 and Day 2 are presented in Figures 5.1 (English) and Figure 5.2 (Spanish). In accordance with our expectations, responding to stimuli in the Spanish version of the task was slower than in the English version and the pattern of results across stimulus types was similar in both languages on both days.

Insert Figures 5.1 and 5.2 About Here

For English word pairs, the effect of stimulus was highly significant, $F(3,51) = 69.43$, $p < .0001$. Associated words were processed more rapidly than were unassociated word, $F(1,53) = 190.24$, $p < .0001$. Responding to two nonwords took longer than responding to both types of two word pairs combined, $F(1,53) = 29.5$, $p < .0001$. And finally, the word-nonword pair was processed slower than the other three pairs combined, $F(1,53) = 114.90$, $p < .0001$. Practice had no effect on matching English stimuli as neither the effect of day nor the interaction of day and stimulus was significant.

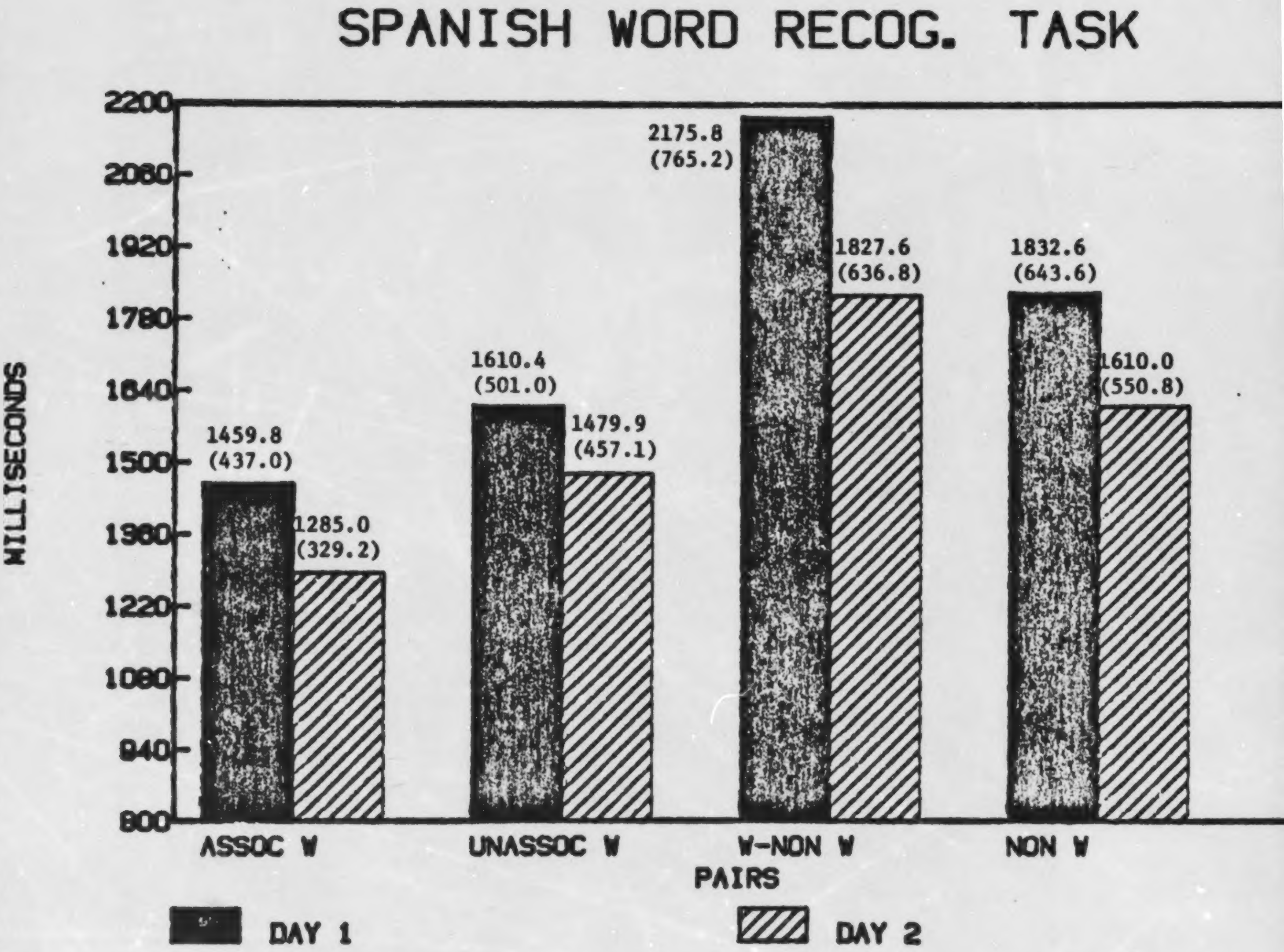
The pattern of stimulus effects when the task was administered in Spanish was similar to that found for the English language task. The main effect of stimulus was highly

FIGURE 5.1



Mean reaction time in milleseconds and the standard deviation for the four types of word pairs in English.

FIGURE 5.2



Mean reaction time in milleseconds and the standard deviation for the four types of word pairs in Spanish.

significant, *F* (3,51) = 49.67, *p* < .0001. Again, associated words were responded to more rapidly than nonassociated words, *F*(1,53) = 60.96, *p* < .0001, and two-word pairs were processed faster than two nonword pairs, F 1,53) = 48.89, *p* < .0001. Furthermore, the reaction time for the word-nonword pair was slower when contrasted with the average reaction time for the three other stimulus pairs, *F* (1,53) = 139.09, *p* < .0001.

Practice had a much stronger effect for the Spanish language task than for the English language task. In the analysis of the Spanish word pairs, reaction times were significantly faster on Day 2 than on Day 1, *F* (1,53) = 16.73, *p* < .0001. The interaction of Stimulus and Day was significant, *F* (3,51) = 4.97, *p* < .004, and this was due primarily to a greater decrease in reaction times from Day 1 to Day 2 for word-nonword pairs than for the other stimuli *F* (1,51) = 13.27, *p* < .001. Thus, although practice reduced the reaction time for all types of word pairs, the effect was strongest for the word-nonword pairs.

The similarity in the pattern of responding in the two languages supports the hypothesis that the same kinds of cognitive processes are involved in recognizing words and accessing semantic memory in Spanish and in English.

As mentioned in the last chapter, interpretation of faster performance in English than in Spanish is not straightforward. Faster performance in English may reflect greater proficiency in that language, and it may also reflect differences in morphology and syllable length across the two languages. Future analysis of the present data might address this issue.

Sentence Verification Task. In this task the subjects judged if a simple sentence-form such as STAR ABOVE PLUS or STAR NOT ABOVE PLUS was a true description of the pictorial stimuli $\overset{*}{+}$ or $\overset{+}{*}$. The presentation of the sentence and the pictorial stimulus were successive and reaction time from the onset of the pictorial stimulus to the subjects response was the dependent variable of primary interest. (Responses to sentences including the preposition "next to" were not analyzed.)

A five factor repeated measures multivariate analysis of variance was performed with verification reaction times as dependent measures. The five factors were: a) Language (Spanish-English); b) Response Type (true-false); c) Sentence Type (affirmative-negative); d) Word Order (star preposition plus, plus preposition star); and e) Preposition (above-below). Only verification RTs for correct responses that were less than 5000 msec and greater than 200 msec were included in the analysis. The group mean RT for a particular item was substituted in place of for RTs for incorrect responses.

The mean reaction times for true and false affirmative and true and false negative trial types, averaged over Word Order and Preposition are illustrated separately for the Spanish and English versions of the task in Figure 5.3. The mean reaction times and error rates for the significant main effects are presented in Table 5.2.

Insert Figure 5.3 and Table 5.2 About Here

Verification RTs were significantly longer for English than for Spanish sentences, F (1,55) = 14.682, $p < .0001$. This unexpected finding may reflect practice effects since the task was always administered in English first. The means and standard deviations for reaction times according to trial type and language of sentences are given in Figure 5.3. Inspection of the differences among means suggests that faster performance in Spanish is present in only two out of four trials types. In only one of these instances (True - Negative) does Spanish performance appear dramaticaly faster than English performance. Furthermore, the fact that reaction time was recorded from the onset of the pictorial stimulus and did not include the sentence encoding phase of the task would also act to minimize the influence of differences in language familiarity on the results. The overall impression one gets from the data is that reaction time was not very different across languages for three out of the four trial types.

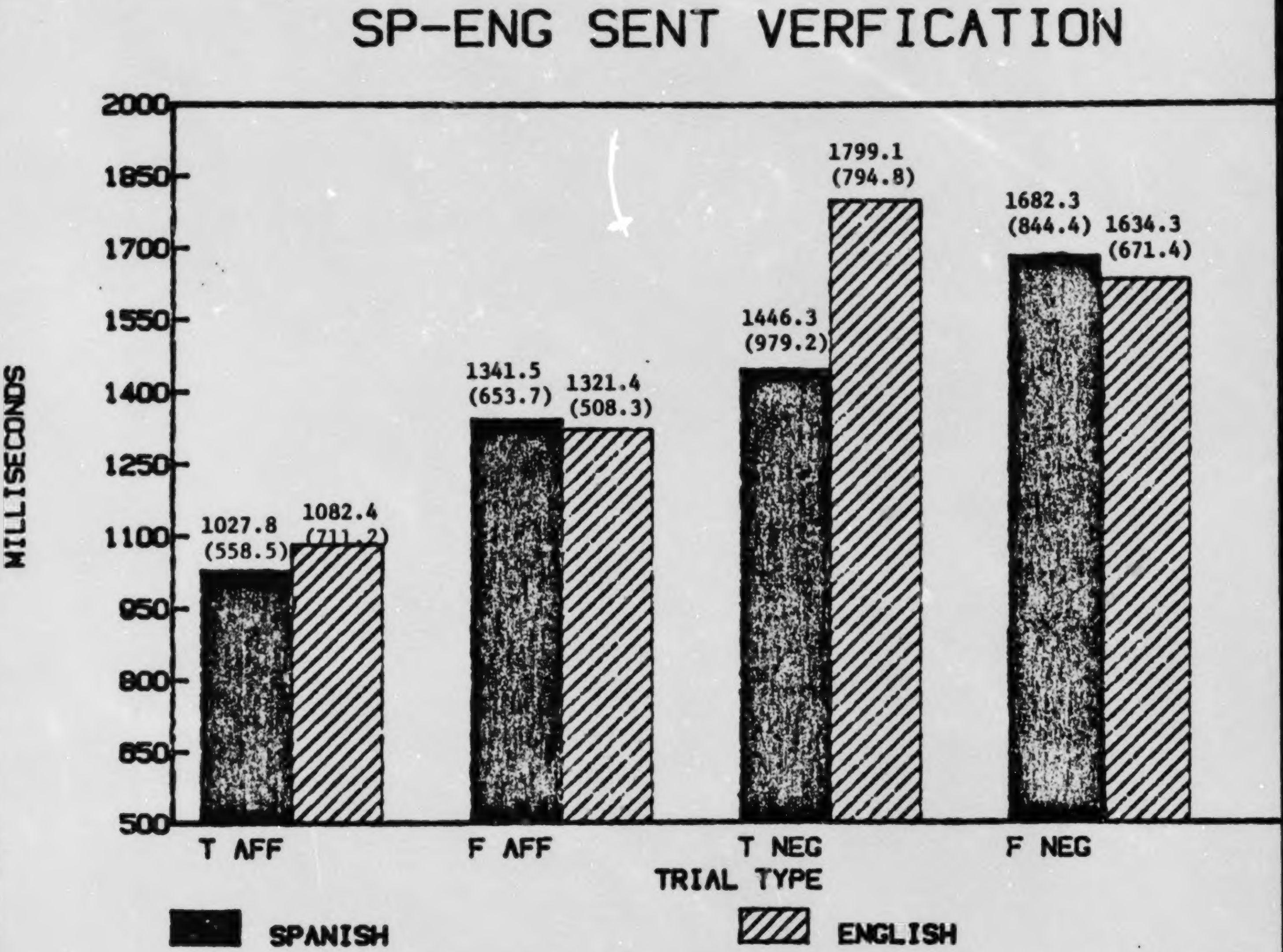
As expected, true responses were made faster than false ones F (1.55) = 18.98, $p < .0001$, and affirmative sentences were responded to faster than negative ones, F (1,55) = 216.937, $p < .0001$. The interaction between Sentence Type and Response type was also significant F (1,55) = 24.36, $p < .0001$. As can be seen in Table 5.3, which collapses across languages, true responses were faster than false responses for affirmative sentences. However, for negative sentences, True and False response times were equal. Thus, the data of this study

Insert Table 5.3 About Here

when collapsed across languages do not support Carpenter and Just's model of sentence verification which predicts that false responses should be faster than true response for negative sentences.

When the reaction time data is examined separately for each language, the results in English are in accordance with the Carpenter and Just model. The results in Spanish are also in accordance with the Carpenter and Just model except that

FIGURE 5.3



Mean reaction time in milleseconds and the standard deviation for four trial types for the Spanish and the English version of the Sentence Verification Task.

Table 5.2

Sentence Verification Task: Mean Reaction Times and Error Rates for Significant Main Effects

	Language	
	English	Spanish
Mean RT	1536.38	1391.98
Error Rate	8.6%	7.3%

	Response Type	
	True	False
Mean RT	1391.37	1536.98
Error Rate	7.5%	8.4%

	Sentence Type	
	Affirmative	Negative
Mean RT	1220.32	1708.04
Error Rate	6.1%	9.7%

Table 5.3

Sentence Verification Task: Mean Reaction Times and Error Rates for the Response Type x Sentence Type Interaction

	Response Type	
Sentence Type	True	False
Affirmative		
Mean RT	1073.00	1367.63
Error Rate	4.5%	7.8%
Negative		
Mean RT	1709.79	1706.34
Error Rate	10.5%	8.9%

latencies for correct true responses to negative sentences are faster than correct false responses to negative sentences. In Chapter 3 it was noted that this sort of deviation from the Carpenter and Just model had been previously found by Hunt and MacLeod (1978) when subjects used a spatial versus linguistic encoding strategy for sentences. Although this pattern of responding for negative sentences appeared to be different for English and Spanish version of the task (see Figure 5.3) the triple interaction of Language x Response Type x Sentence Type was not statistically significant, $F\ (1,55) = 2.49$, $p < .12$. The statistical weakness of this effect, the possibility that practice effects may have occurred because the English version of the task was always presented first, and the lack of measures of spatial ability of subjects makes any attempt to analyze task performance in terms of linguistic or spatial encoding strategies fruitless.

There was a significant interaction between Language and Sentence Type, $F\ (1,55) = 3.954$, $p < .05$. The difference between reaction times for English and Spanish stimuli was greater for negative sentences ($\bar{X} = 1810.00$, English; $\bar{X} = 1606.08$, Spanish) than for affirmative sentences ($\bar{X} = 1262.76$, English; $\bar{X} = 1177.88$, Spanish). Given that the English version of the task was always presented first, the effect of language confounded with order of presentation appears to be strongest for negative sentences.

The interaction between Response Type and Preposition was also significant. True responses were equally fast for both prepositions ($\bar{X} = 1399.25$, "above"; $\bar{X} = 1383.49$, "below"). However, false responses were faster when sentences included "above" ($\bar{X} = 1490.00$) than when sentences included "below" ($\bar{X} = 1589.97$). This latter result is consistent with previous research on the Sentence Verifiction Task (MacLeod, Hunt, and Mathews; 1978).

Finally, the three-way interaction Response Type x Sentence Type x Word Order was also significant, $F\ (1,55) = 6.67$, $p < .01$. The means for this interaction are presented in Table 5.4. For the word order "star preposition plus", true responses are faster than false responses for negative sentences. In contrast, for word order "plus preposition star", true responses are slower than false response for negative sentences.

Insert Table 5.4 About Here

Overall, these results appear to support the hypothesis that the memory code representation for the sentence stimulus did not differ in English and in Spanish and that this representation was in general agreement with a previous theoretical

Table 5.4

Sentence Verification Task: Mean Reaction Times, and Error Rates for the Response Type X Sentence Type X Word Order Interaction

	Response and Sentence Type			
Word Order	True Affirmative	False Affirmative	True Negative	False Negative
Star [preposition] plus				
Mean RT	1114.74	1356.00	1702.97	1763.75
Error Rate	4.5%	7.6%	9.8%	8.9%
Plus [preposition] plus				
Mean RT	1031.272	1379.00	1716.51	1648.93
Error Rate	4.5%	8.0%	11.2%	9.0%

model for this task. The few effects of language that were found are most likely to be practice effects rather than linguistic ones, though it should be noted that this question cannot be answered unambiguously due to the confounding of language of task and language presentation order in the task.

Reading Span Task. This task assessed the subjects' abilities to recall the last words in a series of sentences. Daneman and Carpenter (1980) had found substantial, statistically significant correlations between performance on this task and various measures of general verbal ability in English. Two scores were compiled for each version of the Reading Span Task, a total correct score and a reading span score. The former measure was not reported by Daneman and Carpenter. The reading span score was the highest level (i.e., sentence set size) at which an individual was totally correct on two out of three sets. There was a small but statistically significant difference, t (48) = 3181, $p < .0001$, in the total number of words recalled in English ($\bar{X} = 45.96$, SD - 1.10) and in Spanish ($\bar{X} = 42.27$, SD = 1.31). The mean reading span scores for the English and the Spanish version of the task were 3.55 (SD = 1.23) and 3.31 (SD = 1.36) respectively. These scores were not significantly different from each other and are comparable to the mean reading span score of 3.15 (SD = .93) reported for 20 college students by Daneman and Carpenter (1980). The high correlations between the English and Spanish versions of the task for both the total correct score, r (48) = .69, $p < .0001$, and the reading span score, r (48) = .66, $p < .0001$, indicate good individual consistency across languages.

The results suggest that subjects had a somewhat larger memory span for English words than for Spanish words when the total correct score was used as a performance measure. This interpretation of the data is consistent with the fact that subjects demonstrated stronger proficiency in English than in Spanish. The reading span score used by Daneman and Carpenter and used in this study did not appear to be as sensitive as the total correct score to proficiency differences. The moderately strong correlations between scores on the English and Spanish versions of the task for both score types supports the hypothesis that subjects were using the same memory skills when performing the Reading Span Task in either language.

C. Logical Reasoning Tasks

Syllogisms Task. Overall, the pattern of results found in the present study was quite similar to that reported by Johnson-Laird and Steedman (1978). As can be seen in Table 5.5, accuracy of syllogism solution in the present study was lower than the 68% reported by Johnson-Laird and Steedman. This most likely reflects differences in the subject population given that the procedures were essentially the same in both studies. In the present study, there was a small but significant improvement in accuracy with practice, F (1,48) = 27.3, $p < .0001$, but language had no effect on accuracy. There was considerable differences in the difficulty of the various syllogisms as demonstrated by the Cochran's Q values reported in Table 5.5.

The mean processing time in seconds for the syllogisms in each of the four Language x Day conditions is also reported in Table 5.5. Syllogisms were processed faster in English than in Spanish, F (1,47) = 6.57, $p < .014$, and they were completed faster on Day 2 than on Day 1, F (1,47) = 52.86, $p < .0001$. Thus, while subjects were equally accurate in solving syllogisms in Spanish and in English, they took longer to do so in Spanish--the language in which they were less proficient.

Insert Table 5.5 About Here

The relationships among the total correct scores and processing time in the four Language x Day conditions are reported in Table 5.6. There are very high correlations

----

Insert Table 5.6 About Here

(r's from .84 to .95) between the total correct scores on Day 1 and Day 2 and in English and in Spanish. Similarly, there were strong correlations between processing times from day-to-day and in both languages (r's from .55 to .78). Thus there was high consistency in individual performance over the conditions of the study. It is interesting to note, however, that the correlations between accuracy and processing time were small and positive (r's from .00 to .30). Therefore, on this task more accurate subjects were not necessarily faster at solving the problems.

The results of the present study will be considered in more detail with respect to the mood of the premises, the figure of the syllogisms and the predictions of analogical theory.

The Effects of Mood. Although mood has long been known to affect syllogistic reasoning, Johnson-Laird and Steedman noted that mood in itself is not sufficient to predict the difficulty of a problem nor the types of conclusions it elicits. In Table 5.7, the percent correct for syllogisms classified by

Table 5.5

Mean Percent Correct, Cochran's Q, and Mean Processing Time in Seconds for the Syllogisms in the Four Experimental Conditions

Measure	Experimental Conditions			
	English Day 1	English Day 2	Spanish Day 1	Spanish Day 2
Percent Correct	44	50	47	50
Cochran Q (D.F.)[a]	733.43(63)	753.19(59)	809.26(63)	775.20(59)
Processing Time				
Mean	20.50	14.97	21.35	17.35
S.D.	7.90	5.24	7.58	6.43

[a] All p's < .0001

Table 5.6

Correlations Between Total Correct Scores and Processing Time on Syllogisms Tasks

English	English				Spanish			
	Total Correct		Processing Time		Total Correct		Processing Time	
	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
Total Correct								
Day 1	1.0000 (48) P=*****	0.8893 (47) P=0.000	0.1511 (48) P=0.305	0.1050 (48) P=0.477	0.8434 (48) P=0.000	0.8841 (48) P=0.000	0.1317 (48) P=0.372	0.0044 (48) P=0.976
Day 2	0.8893 * (47) P=0.000	1.0000 (47) P=*****	0.3017 (47) P=0.039	0.2614 (47) P=0.076	0.9457 (47) P=0.000	0.9590 (47) P=0.000	0.1939 (47) P=0.191	0.1002 (47) P=0.503
Processing Time								
Day 1	0.1511 (48) P=0.305	0.3017 * (47) P=0.039	1.0000 (48) P=*****	0.6061 (48) P=0.000	0.3017 (48) P=0.037	0.2156 (48) P=0.141	0.6877 (48) P=0.000	0.5591 (48) P=0.000
Day 2	0.1050 (48) P=0.477	0.2614 + (47) P=0.076	0.6061 * (48) P=0.000	1.0000 (48) P=*****	0.2920 (48) P=0.044	0.2002 (48) P=0.172	0.6614 (48) P=0.000	0.6928 (48) P=0.000
Spanish								
Total Correct								
Day 1	0.8434 * (48) P=0.000	0.9457 * (47) P=0.000	0.3017 * (48) P=0.037	0.2920 * (48) P=0.044	1.0000 (48) P=*****	0.9406 (48) P=0.000	0.2664 (48) P=0.067	0.1929 (48) P=0.189
Day 2	0.8841 * (48) P=0.000	0.9590 * (47) P=0.000	0.2156 (48) P=0.141	0.2002 (48) P=0.172	0.9406 * (48) P=0.000	1.0000 (48) P=*****	0.2080 (48) P=0.156	0.1237 (48) P=0.402
Processing Time								
Day 1	0.1317 (48) P=0.372	0.1939 (47) P=0.191	0.6877 * (48) P=0.000	0.6614 * (48) P=0.000	0.2664 + (48) P=0.067	0.2080 (48) P=0.156	1.0000 (48) P=*****	0.7781 (48) P=0.000
Day 2	0.0044 (48) P=0.976	0.1002 (47) P=0.503	0.5591* (48) P=0.000	0.6928 * (48) P=0.000	0.1929 (48) P=0.189	0.1237 (48) P=0.402	0.7781 (48) P=0.000	1.0000 (48) P=*****

(COEFFICIENT / (CASES) / SIGNIFICANCE) * $p < .05$ + $.05 < p < .10$

the moods of their premises reported by Johnson-Laird and Steedman and found in the present study are presented.

Insert Table 5.7 About Here

In order to determine whether the relative difficulty of the different types of syllogisms was similar among the four experimental conditions of this study and in the Johnson-Laird study, correlations among the five sets of data presented in Table 5.7 were calculated. The resulting correlation matrix is presented in Table 5.8. Within the present study, there is strong agreement (r = .81 to .92) among the four conditions on the relative difficulty of the various types of syllogisms. However, there is only moderate agreement (r = .41 to .54) between the results of the present study and the Johnson-Laird and Steedman experiment. There is a striking pattern of differences in accuracy between the two experiments. The problems for which there is the greatest difference in performance between the two studies are those which consist of two particular premises (i.e., II, IO, OI & OO) or two negative premises (EE, OE, EO, OO).

Insert Table 5.8 About Here

These problems never have a valid conclusion and the high level of accuracy reported for them in the Johnson-Laird study suggest that those subjects may have abstracted rules or recognized "shortcuts" for solving these types of problems.

The Effects of Figure. The striking effects of the figure of the syllogism upon the form of the response reported by Johnson-Laird and Steedman were replicated in the present study and are illustrated in Table 5.9. Most of the responses to the first figure were of the form A-C while the form C-A was the most common response to the fourth figure. Conclusions of the form A-C were also more frequent for both the second and the third figure but the magnitude of the effect was not as great as for the first figure. This small but significant bias for the second and third figure probably reflects the effect of the order of the terms in the premises (A before C) common to all four figures. Bias effects appeared to be of the same magnitude in English and in Spanish.

Insert Table 5.9 About Here

Table 5.7

Percentage Correct Responses in Terms of the Mood of the Premises

	Johnson-Laird and Steedman				Present Experiment															
	Test 2				English Day 1				English Day 2				Spanish Day 1				Spanish Day 2			
	Mood of First Premise																			
Mood of the Second Premise	A	I	E	O	A	I	E	O	A	I	E	O	A	I	E	O	A	I	E	O
A	69	68	51	39	59	57	47	26	65	60	50	40	63	54	48	38	62	53	53	43
I	76	83	60	81	50	38	29	41	58	44	40	47	58	47	28	49	59	46	42	48
E	50	54	71	74	50	24	48	51	51	34	60	48	48	30	57	43	54	35	55	43
O	54	89	78	94	37	50	50	56	49	49	44	65	35	50	42	63	48	56	46	62
Mean % Correct	68%				44%				50%				47%				50%			

Table 5.8

Correlations Among the Percent Correct for Items Classified by Mood of the Premises in the Johnson-Laird and Steedman Study and in the Present Study

	Johnson-Laird & Steedman	English		Spanish	
		Day 1	Day 2	Day 1	Day 2
JL & S	1.0000 (16) P-*****	0.5272 (16) P=0.019	0.4055 (16) P=0.063	0.5409 (16) P=0.017	0.4174 (16) P=0.057
E1	0.5272 (16) P=0.019	1.0000 (16) P=*****	0.8476 (16) P=0.000	0.8343 (16) P=0.000	0.8076 (16) P=0.000
E2	0.4055 (16) P=0.063	0.8476 (16) P=0.000	1.0000 (17) P=*****	0.9076 (16) P=0.000	0.9162 (16) P=0.000
S1	0.5409 (16) P=0.017	0.8343 (16) P=0.000	0.9076 (16) P=0.000	1.0000 (16) P=*****	0.9047 (16) P=0.000
S2	0.4174 (16) P=0.057	0.8076 (16) P=0.000	0.9162 (16) P=0.000	0.9047 (16) P=0.000	1.0000 (16) P=*****

(COEFFICIENT / (CASES) / SIGNIFICANCE)

Table 5.9

The Effect of Figure on the Form of the Conclusion

	Figure of the Premises			
Experiment and Condition	A-B B-C	A-B C-B	B-A B-C	B-A C-B
Johnson-Laird & Steedman				
Day 1				
% A-C	51.2	21.2	31.9	4.7
% C-A	6.2	20.6	17.8	48.1
Day 2				
% A-C	44.7	13.7	29.4	5.3
% C-A	7.8	28.1	25.0	45.3
Present Study				
English Day 1				
% A-C	57.8	30.5	37.0	6.6
% C-A	7.9	23.1	22.4	57.1
t(49)	11.96	2.37	4.96	14.40
p <	.0001	.022	.0001	.0001
English Day 2				
% A-C	64.3	34.5	34.3	6.8
% C-A	6.8	25.1	28.4	58.4
t(49)	13.37	2.94	1.60	-12.84
p <	.0001	.005	.115	.0001

Table 5.9 continued

Experiment and Condition	Figure of the Premises			
	A-B B-C	A-B C-B	B-A B-C	B-A C-B
Present Study				
Spanish Day 1				
% A-C	62.1	30.6	37.3	5.0
% C-A	7.2	24.9	25.7	60.0
$t(50)$	12.71	1.55	2.84	-16.71
$p <$	.0001	.128	.006	.0001
Spanish Day 2				
% A-C	66.8	33.3	34.7	10.7
% C-A	9.2	26.6	30.5	56.7
$t(50)$	13.51	2.07	1.14	-11.92
$p <$	.0001	.044	.260	.0001

As can be seen in Table 5.10, figure also affected accuracy. Separate repeated measures MANOVAS on the effect of Figure in all four conditions of the present experiment, indicated that subjects were more accurate in solving syllogisms of the second and third figure than those of the first and fourth figure.

Insert Table 5.10 About Here

The effect of figure on processing time was unexpected (see Table 5.11). Unbiased syllogisms were not solved more rapidly than biased ones. However, there was a difference in processing time between the two biased figures, with the fourth figure processed more slowly than the first. Possibly this effect reflects the conflict, which occurs only for the fourth figure, between the order in which the terms are encountered in the premises (A before C) and the order of the terms in the preferred response from (C-A).

Insert Table 5.11 About Here

Predictions of the Analogical Theory. In their discussion of their analogical theory of syllogistic reasing, Johnson-Laird and Steedman (1978) list five predictions which follow from the theory. The results reported by these authors with regard to these predictions and comparable results from this study are found in Table 5.12. The first of these predictions is based on whether or not testing of the tentative conclusion leads to any modifications of the conclusion. Obviously, syllogisms for which the initial conclusion is correct will be easier than those for which testing leads to a modified conclusion. This prediction was confirmed for both Spanish and English versions of the Syllogisms Task in the present study.

Insert Table 5.12 About Here

Two other predictions concern syllogisms with valid conclusions and are based on figural effects. For syllogisms for which the initial conclusion is correct, those with two valid converse conclusions or with one valid unidirectional conclusion whose form is congruent with the premises' figural bias will be easier than unidirectional conclusions for unbiased figures. As can be seen in Table 5.12, the results of this study support this prediction.

Table 5.10

The Effect of Figure on Accuracy

Experimental Condition	Figure of Premises				Figure 1 & 4 vs Figure 2 & 3
	A-B B-C	A-B C-B	B-A B-C	B-A C-B	
Johnson-Laird & Steedman					
Day 1	55	64	60	52	
Day 2	67	68	76	62	
Present Study					
English Day 1	38.6	48.7	48.7	41.0	$F(1,49) = 30.925$, $p < .0001$
English Day 2	45.0	52.9	55.6	44.6	$F(1,49) = 25.986$, $p < .0001$
Spanish Day 1	41.7	51.3	51.2	43.9	$F(1,49) = 23.323$, $p < .0001$
Spanish Day 2	46.4	51.6	55.3	46.3	$F(1,49) = 17.749$, $p < .0001$

Table 5.11

Mean Processing Time in Seconds for the Four Figures in Each Experimental Condition

Experimental Condition	Figure of the Premises A-B B-C	 A-B C-B	 B-A B-C	 B-A C-B	Figure 1 vs Figure 2
English Day 1					
$\bar{X}$	19.88	21.33	20.23	20.54	ns
SD	9.43	8.24	7.92	8.27	
English Day 2					
$\bar{X}$	14.43	14.71	14.96	15.63	$F(1,47) = 5.35$ $p < .025$
SD	5.06	6.03	5.79	5.52	
Spanish Day 1					
$\bar{X}$	20.73	20.99	21.35	22.34	$F(1,47) = 10.48$ $p < .002$
SD	7.48	7.58	8.06	8.51	
Spanish Day 2					
$\bar{X}$	16.60	17.57	16.97	18.36	$F(1,47) = 7.60$ $p < .008$
SD	6.34	6.92	6.63	7.24	

Table 5.12

Percent Correct Responses in Relation to

the Predictions of Analogical Theory

	Experimental Condition				
	Johnson-Laird & Steedman	Present Experiment			
		English		Spanish	
Theory Prediction	Day 1	Day 1	Day 2	Day 1	Day 2
1. Unmodified conclusions	80.4	72.1	80.6	76.1	81.4
vs.					
Modified conclusions	46.5	36.5	37.3	38.9	37.4
2. Bidirectional conclusion	88.1	82.2	88.0	85.3	88.4
and					
Unidirectional conclusions in accord with figure bias	85.2				
vs.					
Unidirectional conclusions for unbiased figures	62.5	47.0	62.0	52.9	63.7
3. Conclusion congruent with figural bias	73.3	33.0	53.0	52.0	59.8
vs.					
Conclusion for unbiased figure	50.8	25.0	35.7	27.5	33.7
vs.					
Conclusion opposite in form to figural bias	20.0	7.3	6.4	5.1	11.9
4. Invalid unbiased syllogisms	78.2	50.5	51.9	52.9	51.4
vs.					
Invalid biased syllogisms	64.8	36.4	39.6	38.2	38.9
5. Invalid syllogisms:					
Two affirmative premises					
II	82.5	37.5	43.5	47.1	46.1
AI, IA	47.5	24.5	26.5	23.0	22.0
AA	40.0	46.0	40.0	43.1	39.2
One affirmative, one negative premise					
IE, EI	85.0	45.5	48.0	49.3	51.0
AE, IO, EA, OI	30.0	15.5	16.7	20.6	20.3
AO, OA	---	---	---	---	---
Two negative premises					
OO	93.8	56.0	65.3	62.7	62.0
OE, EO	75.6	50.5	46.3	42.2	44.0
EE	71.3	47.5	60.0	56.9	55.4
Overall					
2 particular premises		52.7	50.4	59.5	52.2
1 universal, 1 particular premise		40.3	34.3	36.6	32.6
2 universal premises		47.2	56.0	54.1	52.0

For syllogisms where a process of logical testing leads to a modified conclusion, the easiest problems will be those where the form of the conclusion is congruent with the bias of the figure. In contrast those syllogisms with conclusions opposite in direction to the figural bias will be most difficult. The solution of unbiased syllogisms will be of intermediate difficulty. Once again, the prediction is confirmed by our observations in both Spanish and English.

Two final predictions concern the ease of solving syllogisms that have no valid conclusions. First, assuming that the easier it is to form paths connecting the end terms, the more difficult it will be to see that there is no valid conclusion, unbiased syllogisms should be easier than biased ones. Our results agree with this prediction made by Johnson-Laird and Steedman theory.

The second prediction concerning invalid syllogisms is based on the assumption that it is easier to modify an initial conclusion when there are fewer paths to falsify. Thus, the difficulty of the syllogism will be related to whether the premises are particular or universal. As can be seen in Table 5.12, this prediction is not supported by the results of our study. In the present study, the most difficult invalid syllogisms were those with one particular and one universal premise. This is not surprising because the two other combinations of premises can be solved by applying simple rules. Two particular premises never have a valid conclusion and, for four out of five invalid syllogisms with two universal premises, both premises were negative and thus easily solved.

Overall, there is remarkably good agreement between the results of the present study for both the Spanish and English versions of the task and the predictions of Johnson-Laird and Steedman's theory. However, the results of the present study do suggest that a limitation of the theory is that it describes the way subjects solve valid syllogisms better than the way they may solve invalid ones. Although Johnson-Laird and Steedman noted that shortcuts could be used to solve many invalid syllogisms, this factor was not fully incorporated into the predictions of the theory. This is a potentially fruitful area for further investigation as there may be qualitative differences in the way individuals approach and solve these problems.

With respect to influence of bilingualism on syllogistic reasoning, it is somewhat surprising that there was not a greater difference in accuracy between the two versions of the task. However, the fact that it took subjects longer to solve syllogisms in Spanish indicates that when subjects are allowed sufficient time to encode relatively unfamiliar linguistic stimuli, they can be just as efficient at manipulating these representations and reasoning about them. This possibility has implications for understanding better how bilingualism may affect performance of complex cognitive tasks where a tradeoff may exist between accuracy and speed of performance.

Logical Reasoning and Inference Tests. The mean scores and standard deviation for scores on the paper and pencil tests of logical reasoning and inference are presented in Table 5.13. Surprisingly, subjects performed significantly better in Spanish than in English on the Logical Reasoning test, $t\ (54) = 2.47$, $p < .017$. This effect may reflect practice effects since the English version of the test was given first. The very high correlation between the two versions of the test, $r\ (54) = .70$, $p < .0001$, supports the idea that common skills were measured by both tests. In contrast to the foregoing results, performance was higher on the English version of the Inference Test than on the Spanish version, $t\ (54) = 6.99$, $p < .0001$. The correlation between the two versions of this task was low and nonsignificant, $r\ (54) = .21$, $p < .066$. The low intercorrelation may reflect the relatively low internal reliability of these tests and this needs further investigation. Despite this possibility, the Inference Test appeared to be more strongly affected by language of administration than did the Logical Reasoning Test.

Insert Table 5.13 About Here

D. Relationships Among Tasks

The final area of analysis concerned the associations between performance on the various tasks and tests. The three sets of relationships of central interest were: a) those between performance on the Syllogism Task and performance on the paper and pencil tests of reading comprehension and reasoning; b) those between performance on the Syllogism Task and on the other cognitive tasks; and c) those between the paper and pencil tests and the other cognitive tasks.

Syllogisms Task and Reading and Reasoning Tests. As expected there were a number of significant correlations between the measures of performance on the Syllogisms Task and on the paper and pencil tests of reading and reasoning (see Table 5-14.

Insert Table 5-14 About Here

Table 5.13

Comparison of Performance on
Spanish and English Version of the
Logical Reasoning and Inference Tests

Test	Language English	 Spanish
Logical Reasoning		
Mean	15.42	16.22
SD	2.62	3.37
Inference		
Mean	7.40	5.18
SD	1.45	2.18

Table 5.14

Correlations Between Performance on the Syllogism Task and on the Reading, Logical Reasoning and Inference Tests

	Syllogism Task							
	English				Spanish			
English Tests	Total Correct		Processing Time		Total Correct		Processing Time	
Reading	Day 1		Day 1	Day 2	Day 1	Day 2	Day 1	Day 2
Vocabulary	0.3618 * (48) P=0.011	0.2928 * (47) P=0.046	0.1694 (48) P=0.250	0.3044 * (48) P=0.035	0.3091 * (48) P=0.033	0.2878 * (48) P=0.047	0.1438 (48) P=0.329	0.0509 (48) P=0.731
Speed	0.1015 (48) P=0.492	0.0845 (47) P=0.572	-0.0098 (48) P=0.947	-0.0627 (48) P=0.672	0.0981 (48) P=0.507	0.0415 (48) P=0.779	-0.1041 (48) P=0.481	-0.2979 * (48) P=0.040
Level	0.2620 + (48) P=0.072	0.3275 * (47) P=0.025	-0.0451 (48) P=0.761	-0.0386 (48) P=0.794	0.2678 + (48) P=0.066	0.2743 + (48) P=0.059	-0.2612 + (48) P=0.073	-0.3230 * (48) P=0.025
Total	0.2936 * (48) P=0.043	0.2910 * (47) P=0.047	0.0458 (48) P=0.757	0.0775 (48) P=0.600	0.2727 + (48) P=0.061	0.2449 + (48) P=0.093	-0.1017 (48) P=0.492	-0.2461 + (48) P=0.092
Logical Reasoning	0.1637 (48) P=0.266	0.2220 (47) P=0.134	-0.1255 (48) P=0.395	-0.1387 (48) P=0.347	0.1517 (48) P=0.303	0.1804 (48) P=0.220	-0.1551 (48) P=0.292	-0.1896 (48) P=0.197
Inference	0.2290 (47) P=0.128	0.1358 (46) P=0.368	-0.3695 * (47) P=0.011	-0.1761 (47) P=0.236	0.0963 (47) P=0.520	0.1481 (47) P=0.320	-0.3153 * (47) P=0.031	-0.3325 * (47) P=0.022
Spanish Tests								
Reading								
Vocabulary	0.2257 (48) P=0.123	0.2863 * (47) P=0.051	0.0015 (48) P=0.992	0.0369 (48) P=0.803	0.2560 + (48) P=0.079	0.2309 (48) P=0.114	-0.1732 (48) P=0.239	-0.2014 (48) P=0.170
Speed	-0.0740 (48) P=0.617	-0.0246 (47) P=0.870	0.0489 (48) P=0.741	0.1085 (48) P=0.463	-0.0320 (48) P=0.829	-0.1005 (48) P=0.497	-0.1685 (48) P=0.252	-0.2086 (48) P=0.155
Level	0.1812 (48) P=0.218	0.2541 + (47) P=0.085	-0.0659 (48) P=0.656	-0.0428 (48) P=0.773	0.2288 (48) P=0.118	0.1667 (48) P=0.257	-0.2587 + (48) P=0.076	-0.3170 * (48) P=0.028
Total	0.1722 (48) P=0.242	0.2364 (47) P=0.110	-0.0109 (48) P=0.941	0.0286 (48) P=0.847	0.2100 (48) P=0.152	0.1545 (48) P=0.294	-0.2227 (48) P=0.128	-0.2707 + (48) P=0.063
Logical Reasoning	0.2846 * (48) P=0.053	0.2988 * (47) P=0.041	-0.2973 * (48) P=0.040	-0.2041 (48) P=0.164	0.2152 (48) P=0.142	0.2578 + (48) P=0.077	-0.3250 * (48) P=0.024	-0.3177 * (48) P=0.028
Inference	0.2096 (47) P=0.157	0.2216 (46) P=0.139	-0.1850 (47) P=0.213	-0.0352 (47) P=0.814	0.1599 (47) P=0.283	0.2117 (47) P=0.153	-0.2632 + (47) P=0.074	-0.2511 (47) P=0.089

(COEFFICIENT / (CASES) / SIGNIFICANCE) * p < .05 + .05 < p < .10

The patterns of relationships however were not consistent across languages. Performance on the English Reading Comprehension Test was correlated with accuracy on the English Syllogism Task and also tended to be correlated with performance on the Spanish Syllogisms Task. In contrast with this, there were few significant correlations between scores on the Spanish Reading Comprehension Test and performance on either the Spanish or English Syllogism Task.

Unexpectedly, there were larger correlations for performance on both the English and the Spanish Syllogisms Tasks with scores on the Spanish version of the Logical Reasoning Test than with the English version. Recall that the scores on the Spanish reasoning test were higher than those on the English version, possibly reflecting a practice effect. Thus performance on the Spanish version may be a better estimate of reasoning skill.

Scores on the English Inference test were associated with processing time on both the English (Day 1 only) and Spanish Syllogisms Tasks.

Overall, correlations between scores on the tests of reading and reasoning tended to be stronger for the accuracy measures on the English version of the Syllogisms task and for processing time measures on the Spanish version.

Syllogisms Task and Elementary Cognitive Tasks. The correlations between performance on the Syllogism Task and on the Word Recognition, Reading Span and Sentence Verification Tasks are presented in Table 5.15 for the English tasks and in Table 5.16 for the Spanish tasks. For the English tasks there were significant correlations between accuracy on the Syllogisms Task and speed in processing unassociated words and word-nonwords pairs and in verifying false affirmative sentences. Similarly, for the Spanish tasks there were some significant correlations between performance on the Syllogism Task and on the Word Recognition and the Sentence Verification Task. The Reading Span measures failed to correlate with performance on the Syllogism Task in either language.

Insert Tables 5.15 and 5.16 About Here

In summary, the pattern of correlations is neither strong enough or consistent enough to provide clear insights into the relationship among the tasks. However, the fact that the same types of measures tended to be associated for both the English and the Spanish versions of the tasks is indicative of underlying similarity in the structure of cognitive processing despite differences in the language of input.

Table 5.15

Correlations Between Performance on the English Versions
of the Syllogism Task and the Elementary Cognitive Tasks

	Total Correct		Processing Time	
Word Recognition	Day 1	Day 2	Day 1	Day 2
Assoc. Words	-0.2224 (47) P=0.133	-0.2165 (46) P=0.148	0.0070 (47) P=0.963	-0.0806 (47) P=0.590
Unassoc. Words	-0.3031 * (47) P=0.038	-0.3068 * (46) P=0.038	0.0212 (47) P=0.888	-0.0856 (47) P=0.567
Word-Non Word	-0.2782 + (47) P=0.058	-0.2926 * (46) P=0.048	0.0227 (47) P=0.879	0.0336 (47) P=0.822
Two Non Words	-0.2419 + (47) P=0.101	-0.2356 (46) P=0.115	0.0191 (47) P=0.899	0.0443 (47) P=0.767
Reading Span				
Total Correct	0.2264 (44) P=0.139	0.2440 (43) P=0.115	0.0838 (44) P=0.588	-0.1248 (44) P=0.420
Achieve. Level	0.1443 (44) P=0.353	0.1819 (43) P=0.243	0.1395 (44) P=0.366	0.0546 (44) P=0.725
Sentence Verification				
True Affirm.	0.0998 (48) P=0.500	0.1736 (47) P=0.243	-0.0053 (48) P=0.972	0.0383 (48) P=0.796
True Neg.	-0.1034 (48) P=0.484	-0.0837 (47) P=0.576	-0.1590 (48) P=0.280	-0.0807 (48) P=0.586
False Affirm.	-0.2877 * (48) P=0.047	-0.1341 (47) P=0.369	0.1365 (48) P=0.355	0.2130 (48) P=0.146
False Neg.	-0.1215 (48) P=0.411	-0.1085 (47) P=0.468	-0.0890 (48) P=0.547	-0.0096 (48) P=0.949

(COEFFICIENT / (CASES) / SIGNIFICANCE) * $p < .05$ + $.05 < p < .10$

Table 5.16

Correlations Between Performance on the Spanish Versions of the Syllogism Task and the Elementary Cognitive Tasks

	Total Correct		Processing Time	
Word Recognition	Day 1	Day 2	Day 1	Day 2
Assoc. Words	-0.2333 (48) P=0.110	-0.2436 + (48) P=0.095	-0.0743 (48) P=0.616	-0.0056 (48) P=0.970
Unassoc. Words	-0.2641 + (48) P=0.070	-0.3026 * (48) P=0.036	-0.0282 (48) P=0.849	-0.0098 (48) P=0.947
Word-Nonword	-0.2464 + (48) P=0.091	-0.3239 * (48) P=0.025	0.0225 (48) P=0.879	0.0843 (48) P=0.569
Two Nonwords	-0.3119 * (48) P=0.031	-0.3476 * (48) P=0.015	-0.0261 (48) P=0.860	0.0741 (48) P=0.617
Reading Span				
Total Correct	0.0741 (43) P=0.637	0.0345 (43) P=0.826	-0.2362 (43) P=0.127	-0.3443 * (43) P=0.024
Achieve. Level	0.1137 (43) P=0.468	0.0487 (43) P=0.756	0.0747 (43) P=0.634	-0.0896 (43) P=0.568
Sentence Verification				
True Affirm.	-0.0837 (48) P=0.572	-0.0368 (48) P=0.804	-0.1441 (48) P=0.328	-0.1045 (48) P=0.480
True Neg.	-0.1846 (48) P=0.209	-0.2175 (48) P=0.137	-0.1001 (48) P=0.498	0.0006 (48) P=0.997
False Affirm.	-0.1589 (48) P=0.281	-0.1983 (48) P=0.177	-0.2226 (48) P=0.128	-0.0855 (48) P=0.563
False Neg.	-0.3333 * (48) P=0.021	-0.3410 * (48) P=0.018	-0.1417 (48) P=0.336	-0.0019 (48) P=0.990

(COEFFICIENT / (CASES) / SIGNIFICANCE) * $p < .05$ + $.05 < p < .10$

Tests of Reading and Reasoning and Elementary Cognitive Tasks. The associations among the Reading, Logical Reasoning and Inference Tests and the Elementary Cognitive Tasks are reported in Table 5.18 for the English tests and in Table 5.18 for the Spanish tests. For the English versions of these tasks, the paper and pencil test of Reading Comprehension, Logical Reasoning and Inference are interrelated. These associations were expected in view of the similarity in format and content among the tests. There were a number of significant correlations between performance on the Word Recognition Task and Reading Comprehension scores. However, Reading Span performance failed to correlate as strongly with Reading Comprehension scores as expected on the basis of previous research although it did correlate significantly with Word Recognition Performance. Finally, as predicted, the Sentence Verification measures, which were independent of time required to read sentences, were not associated with Reading Comprehension test scores.

Insert Tables 5.17 and 5.18 About Here

It was expected that associations among the tasks should be more pronounced for the Spanish version of tests since the subjects' skill was more variable and critical to task performance. As can be seen in Table 5.18 this prediction was confirmed. The correlations among the tests of Reading Comprehension, Logical Reasoning and Inference were very strong. The Word Recognition measures also correlated with performance on these paper and pencil tests. In contrast with the results for the English language conditions, the Spanish Reading Span scores were correlated with Reading Comprehension. Once again, however, performance on the Sentence Verification Task was found to be unassociated with the other measures.

Table 5.17

Correlations Among Performance on Reading, Logical Reasoning, Inference Tests and Elementary Cognitive Tasks for English Language Condition

	Reading				Logical Reasoning	Inference	Word Recognition			
Reading	Vocab.	Speed	Level	Total			Assoc. Word	Unassoc. Words	Word- Nonword	Two Nonwords
Vocab	1.0000 (56) P=*****	0.4364 * (56) P=0.001	0.5331 * (56) P=0.000	0.7962 * (56) P=0.000	0.0819 (55) P=0.552	0.2072 (55) P=0.129	-0.1510 (55) P=0.271	-0.2525 + (55) P=0.063	-0.2815 * (55) P=0.037	-0.2614 * (55) P=0.054
Speed	0.4364 * (56) P=0.001	1.0000 (56) P=*****	0.4812 * (56) P=0.000	0.7888 * (56) P=0.000	0.1352 (55) P=0.325	0.2188 (55) P=0.109	-0.1382 (55) P=0.314	-0.2726 * (55) P=0.044	-0.2068 (55) P=0.130	-0.1792 (55) P=0.191
Level	0.5331 * (56) P=0.003	0.4812 * (56) P=0.000	1.0000 (56) P=*****	0.8420 * (56) P=0.000	0.3802 * (55) P=0.004	0.3932 * (55) P=0.003	-0.1212 (55) P=0.378	-0.2545 + (55) P=0.061	-0.2017 (55) P=0.140	-0.1821 (55) P=0.183
Total	0.7962 * (56) P=0.000	0.7888 * (56) P=0.000	0.8420 * (56) P=0.000	1.0000 (56) P=*****	0.2521 + (55) P=0.063	0.3423 * (55) P=0.011	-0.1637 (55) P=0.232	-0.3169 * (55) P=0.018	-0.2783 * (55) P=0.040	-0.2513 + (55) P=0.064
Logical Reasoning	0.0819 (55) P=0.552	0.1352 (55) P=0.325	0.3802 * (55) P=0.004	0.2521 + (55) P=0.063	1.0000 (55) P=*****	0.3713 * (54) P=0.006	0.0231 (54) P=0.868	0.0294 (54) P=0.833	0.1294 (54) P=0.351	0.1225 (54) P=0.378
Inference	0.2072 (55) P=0.129	0.2188 (55) P=0.109	0.3932 * (55) P=0.003	0.3423 * (55) P=0.011	0.3713 * (54) P=0.006	1.0000 (55) P=*****	-0.1933 (54) P=0.161	-0.2010 (54) P=0.145	-0.0894 (54) P=0.520	-0.1168 (54) P=0.400
Word Recognition										
Assoc. Words	-0.1510 (55) P=0.271	-0.1382 (55) P=0.314	-0.1212 (55) P=0.378	-0.1637 (55) P=0.232	0.0231 (54) P=0.868	-0.1933 (54) P=0.161	1.0000 (55) P=*****	0.9175 * (55) P=0.000	0.8137 * (55) P=0.000	0.7388 * (55) P=0.000
Unassoc. Words	-0.2525 + (55) P=0.063	-0.2726 * (55) P=0.044	-0.2545 + (55) P=0.061	-0.3169 * (55) P=0.018	0.0294 (54) P=0.833	-0.2010 (54) P=0.145	0.9175 * (55) P=0.000	1.0000 (55) P=*****	0.8700 * (55) P=0.000	0.7812 * (55) P=0.000
Word-Nonword	-0.2815 * (55) P=0.037	-0.2068 (55) P=0.130	-0.2017 (55) P=0.140	-0.2783 * (55) P=0.040	0.1294 (54) P=0.351	-0.0894 (54) P=0.520	0.8137 * (55) P=0.000	0.8700 * (55) P=0.000	1.0000 (55) P=*****	0.9153 * (55) P=0.000
Two Nonwords	-0.2614 * (55) P=0.054	-0.1792 (55) P=0.191	-0.1821 (55) P=0.183	-0.2513 + (55) P=0.064	0.1225 (54) P=0.378	-0.1168 (54) P=0.400	0.7388 * (55) P=0.000	0.7812 * (55) P=0.000	0.9153 * (55) P=0.000	1.0000 (55) P=*****

Table 5.17 (continued)

Sentence Verification	Reading				Logical Reasoning	Inference	Word Recognition			
	Vocab.	Speed	Level	Total			Assoc. Word	Unassoc. Words	Word-Nonword	Two Nonwords
True Affirm.	0.0684 (56) P=0.616	-0.0113 (56) P=0.934	0.2716 * (56) P=0.043	0.1448 (56) P=0.287	0.0001 (55) P=0.959	-0.1111 (55) P=0.420	0.0719 (55) P=0.602	0.0372 (55) P=0.787	0.0243 (55) P=0.860	-0.0063 (55) P=0.963
True Neg.	0.0070 (56) P=0.959	-0.0900 (56) P=0.510	0.0213 (56) P=0.876	-0.0193 (56) P=0.888	0.0169 (55) P=0.902	-0.0295 (55) P=0.831	0.1015 (55) P=0.461	0.0833 (55) P=0.545	0.0365 (55) P=0.791	-0.0100 (55) P=0.942
False Affirm.	-0.0689 (56) P=0.614	-0.0823 (56) P=0.547	-0.0030 (56) P=0.983	-0.0599 (56) P=0.661	0.0441 (55) P=0.749	-0.2258 + (55) P=0.097	0.2389 + (55) P=0.079	0.2715 * (55) P=0.045	0.2146 (55) P=0.116	0.1985 (55) P=0.146
False Neg.	-0.0574 (56) P=0.674	-0.1485 (56) P=0.275	-0.0030 (56) P=0.982	-0.0797 (56) P=0.559	-0.2520 + (55) P=0.063	-0.2021 (55) P=0.139	0.2600 + (55) P=0.055	0.2626 * (55) P=0.053	0.2474 + (55) P=0.069	0.1766 (55) P=0.197
Reading Span										
Total Correct	0.1195 (51) P=0.403	0.0789 (51) P=0.582	0.1962 (51) P=0.168	0.1635 (51) P=0.252	0.0966 (50) P=0.505	-0.0931 (50) P=0.520	-0.2996 * (50) P=0.035	-0.2972 * (50) P=0.036	-0.3113 * (50) P=0.028	-0.1833 (50) P=0.202
Achieve. Level	0.2732 * (51) P=0.052	0.0852 (51) P=0.552	0.1923 (51) P=0.176	0.2233 (51) P=0.115	0.0600 (50) P=0.679	-0.0402 (50) P=0.782	-0.1802 (50) P=0.211	-0.1207 (50) P=0.404	-0.2171 (50) P=0.130	-0.1077 (50) P=0.457

Reading	Sentence Verification				Reading Span	
	True Affirm.	True Neg.	False Affirm	False Neg.	Total Correct	Achieve. Level
Vocab.	0.0684 (56) P=0.616	0.0070 (56) P=0.959	-0.0689 (56) P=0.614	-0.0574 (56) P=0.674	0.1195 (51) P=0.403	0.2732 * (51) P=0.052
Speed	-0.0113 (56) P=0.934	-0.0900 (56) P=0.510	-0.0823 (56) P=0.547	-0.1485 (56) P=0.275	0.0789 (51) P=0.582	0.0852 (51) P=0.552
Level	0.2716 * (56) P=0.043	0.0213 (56) P=0.876	-0.0030 (56) P=0.983	-0.0030 (56) P=0.982	0.1962 (51) P=0.168	0.1923 (51) P=0.176
Total	0.1448 (56) P=0.287	-0.0193 (56) P=0.888	-0.0599 (56) P=0.661	-0.0797 (56) P=0.559	0.1635 (51) P=0.252	0.2233 (51) P=0.115

Table 5.17 (continued)

	Sentence Verification				Reading Span	
	True Affirm.	True Neg.	False Affirm.	False Neg.	Total Correct	Achieve. Level
Logical Reasoning	0.0001 (55) P=0.999	0.0169 (55) P=0.902	0.0441 (55) P=0.749	-0.2520 * (55) P=0.063	0.0966 (50) P=0.505	0.0600 (50) P=0.679
Inference	-0.1111 (55) P=0.420	-0.0295 (55) P=0.831	-0.2258 + (55) P=0.097	-0.2021 (55) P=0.139	-0.0931 (50) P=0.520	-0.0402 (50) P=0.782
Word Recognition						
Assoc. Words	0.0719 (55) P=0.602	0.1015 (55) P=0.461	0.2389 + (55) P=0.079	0.2600 + (55) P=0.055	-0.2996 * (50) P=0.035	-0.1802 (50) P=0.211
Unassoc. Words	0.0372 (55) P=0.787	0.0833 (55) P=0.545	0.2715 * (55) P=0.045	0.2626 * (55) P=0.053	-0.2972 * (50) P=0.036	-0.1207 (50) P=0.404
Word-Nonword	0.0243 (55) P=0.860	0.0365 (55) P=0.791	0.2146 (55) P=0.116	0.2474 + (55) P=0.069	-0.3113 * (50) P=0.028	-0.2171 (50) P=0.130
Two Nonwords	-0.0063 (55) P=0.963	-0.0100 (55) P=0.942	0.1985 (55) P=0.146	0.1766 (55) P=0.197	-0.1833 (50) P=0.202	-0.1077 (50) P=0.457
Sentence Verification						
True Affirm.	1.0000 (56) P=*****	0.6184 * (56) P=0.000	0.2650 * (56) P=0.048	0.4379 * (56) P=0.001	-0.0226 (51) P=0.875	-0.0616 (51) P=0.668
True Neg.	0.6184 * (56) P=0.000	1.0000 (56) P=*****	0.5158 * (56) P=0.000	0.6124 * (56) P=0.000	-0.0614 (51) P=0.669	-0.0236 (51) P=0.870
False Affirm.	0.2650 * (56) P=0.048	0.5158 * (56) P=0.000	1.0000 (56) P=*****	0.4968 (56) P=0.000	0.1267 (51) P=0.376	0.1957 (51) P=0.169
False Neg.	0.4379 * (56) P=0.001	0.6124 * (56) P=0.000	0.4968 * (56) P=0.000	1.0000 (56) P=*****	0.0576 (51) P=0.688	0.0536 (51) P=0.709

Table 5.17 (continued)

	Sentence Verification				Reading Span	
Reading Span	True Affirm.	True Neg.	False Affirm.	False Neg.	Total Correct	Achieve. Level
Total Correct	-0.0226 (51) P=0.875	-0.0614 (51) P=0.669	0.1267 (51) P=0.376	0.0576 (51) P=0.688	1.0000 (51) P=*****	0.7618 * (51) P=0.000
Achieve. Level	-0.0616 (51) P=0.668	-0.0236 (51) P=0.870	0.1957 (51) P=0.169	0.0536 (51) P=0.709	0.7618 * (51) P=0.000	1.0000 (51) P=*****

(COEFFICIENT / (CASES) / SIGNIFICANCE)

Table 5.18

Correlations Among Performance on Reading, Logical Reasoning, Inference Tests and Elementary Cognitive Tasks for Spanish Language Condition

	Reading				Logical Reasoning	Inference	Word Recognition (Day 2)			
Reading	Vocab.	Speed	Level	Total			Assoc. Words	Unassoc. Words	Word-Nonword	Two Nonwords
Vocab.	1.0000 (56) P=*****	0.6397 * (56) P=0.000	0.7362 * (56) P=0.000	0.9016 * (56) P=0.000	0.5684 * (55) P=0.000	0.6142 * (55) P=0.000	-0.4292 * (56) P=0.001	-0.3802 * (56) P=0.004	-0.2764 * (55) P=0.041	-0.3390 * (56) P=0.011
Speed	0.6397 * (56) P=0.000	1.0000 (56) P=*****	0.6321 * (56) P=0.000	0.8170 * (56) P=0.000	0.2213 + (55) P=0.104	0.6261 * (55) P=0.000	-0.3364 * (56) P=0.011	-0.2556 + (56) P=0.057	-0.1605 (55) P=0.242	-0.2316 + (56) P=0.086
Level	0.7362 * (56) P=0.000	0.6321 * (56) P=0.000	1.0000 (56) P=*****	0.9152 * (56) P=0.000	0.4158 * (55) P=0.002	0.5834 * (55) P=0.000	-0.3714 * (56) P=0.005	-0.3224 * (56) P=0.015	-0.2491 (55) P=0.067	-0.2463 + (56) P=0.067
Total	0.9016 * (56) P=0.000	0.8170 * (56) P=0.000	0.9152 * (56) P=0.000	1.0000 (56) P=*****	0.4752 * (55) P=0.000	0.6850 * (55) P=0.000	-0.4429 * (56) P=0.001	-0.3798 * (56) P=0.004	-0.2800 * (55) P=0.038	-0.3193 * (56) P=0.016
Logical Reasoning	0.5684 * (55) P=0.000	0.2213 + (55) P=0.104	0.4158 * (55) P=0.002	0.4752 * (55) P=0.000	1.0000 (55) P=*****	0.3831 * (54) P=0.004	-0.2377 + (55) P=0.080	-0.2631 * (55) P=0.052	-0.2152 (54) P=0.118	-0.2415 + (55) P=0.076
Inference	0.6142 * (55) P=0.000	0.6261 * (55) P=0.000	0.5834 * (55) P=0.000	0.6850 * (55) P=0.000	0.3831 * (54) P=0.004	1.0000 (55) P=*****	-0.2616 * (55) P=0.054	-0.2706 * (55) P=0.046	-0.2191 (54) P=0.111	-0.2837 * (55) P=0.036
Word Recognition										
Assoc. Words	-0.4292 * (56) P=0.001	-0.3364 * (56) P=0.011	-0.3714 * (56) P=0.005	-0.4429 * (56) P=0.001	-0.2377 * (55) P=0.080	-0.2616 * (55) P=0.054	1.0000 (56) P=*****	0.9032 * (56) P=0.000	0.8530 * (55) P=0.000	0.8839 * (56) P=0.000
Unassoc. Words	-0.3802 * (56) P=0.004	-0.2556 + (56) P=0.057	-0.3224 * (56) P=0.015	-0.3798 * (56) P=0.004	-0.2631 * (55) P=0.052	-0.2706 * (55) P=0.046	0.9032 * (56) P=0.000	1.0000 (56) P=*****	0.8494 * (55) P=0.000	0.8703 * (56) P=0.000
Word-Nonword	-0.2764 * (55) P=0.041	-0.1605 (55) P=0.242	-0.2491 + (55) P=0.067	-0.2800 * (55) P=0.038	-0.2152 (54) P=0.118	-0.2191 (54) P=0.111	0.8530 * (55) P=0.000	0.8494 * (55) P=0.000	1.0000 (55) P=*****	0.9034 * (55) P=0.000
Two Nonwords	-0.3390 * (56) P=0.011	-0.2316 + (56) P=0.086	-0.2463 + (56) P=0.067	-0.3193 * (56) P=0.016	-0.2415 + (55) P=0.076	-0.2837 * (55) P=0.036	0.8839 * (56) P=0.000	0.8703 * (56) P=0.000	0.9034 * (55) P=0.000	1.0000 (56) P=*****

Table 5.18 (continued)

Sentence Verification	Reading Vocab.	Speed	Level	Total	Logical Reasoning	Inference	Word Recognition (Day 2) Assoc. Word	Unassoc. Words	Word-Nonword	Two Nonwords
True Affirm.	0.0406 (56) P=0.766	-0.0208 (56) P=0.879	-0.0416 (56) P=0.761	-0.0155 (56) P=0.910	0.0474 (55) P=0.759	0.0723 (55) P=0.600	0.0357 (56) P=0.794	0.0422 (56) P=0.757	0.0401 (55) P=0.771	0.0153 (56) P=0.911
True Neg.	-0.0984 (56) P=0.471	0.0486 (56) P=0.722	-0.0238 (56) P=0.862	-0.0351 (56) P=0.797	-0.2931 * (55) P=0.030	0.0362 (55) P=0.793	0.1538 (56) P=0.258	0.1612 (56) P=0.235	0.2207 (55) P=0.105	0.1563 (56) P=0.250
False Affirm.	0.0139 (56) P=0.919	0.0505 (56) P=0.712	-0.0233 (56) P=0.864	0.0000 (56) P=1.000	-0.0531 (55) P=0.700	0.0257 (55) P=0.852	0.0697 (56) P=0.610	0.1860 (56) P=0.170	0.1327 (55) P=0.334	0.0879 (56) P=0.519
False Neg.	-0.2540 + (56) P=0.059	-0.0702 (56) P=0.607	-0.2039 (56) P=0.132	-0.2179 (56) P=0.107	-0.3335 * (55) P=0.013	-0.1487 (55) P=0.278	0.1977 (56) P=0.144	0.2364 + (56) P=0.079	0.1701 (55) P=0.214	0.2179 (56) P=0.107
Reading Span										
Total Correct	0.4353 * (50) P=0.002	0.4279 * (50) P=0.002	0.2852 * (50) P=0.045	0.4029* (50) P=0.004	0.3331 * (49) P=0.019	0.2508 + (49) P=0.082	-0.1973 (50) P=0.170	-0.1903 (50) P=0.186	-0.0191 (49) P=0.897	-0.1322 (50) P=0.360
Achieve. Level	0.2963 * (50) P=0.037	0.2888 * (50) P=0.042	0.0992 (50) P=0.493	0.2296 (50) P=0.109	0.2189 (49) P=0.131	0.1659 (49) P=0.255	-0.0272 (50) P=0.851	-0.0047 (50) P=0.974	0.0652 (49) P=0.656	0.0096 (50) P=0.947

Reading	Sentence Verification True Affirm.	True Neg.	False Affirm.	False Neg.	Reading Span Total Correct	Achieve. Level
Vocab.	0.0406 (56) P=0.766	-0.0984 (56) P=0.471	0.0139 (56) P=0.919	-0.2540 (56) P=0.059	0.4353 * (50) P=0.002	0.2963 * (50) P=0.037
Speed	-0.0208 (56) P=0.879	0.0486 (56) P=0.722	0.0505 (56) P=0.712	-0.0702 (56) P=0.607	0.4279 * (50) P=0.002	0.2888 * (50) P=0.042
Level	-0.0416 (56) P=0.761	-0.0238 (56) P=0.862	-0.0233 (56) P=0.864	-0.2039 (56) P=0.132	0.2852 * (50) P=0.045	0.0992 (50) P=0.493
Total	-0.0155 (56) P=0.910	-0.0351 (56) P=0.797	0.0000 (56) P=1.000	-0.2179 (56) P=0.107	0.4029* (50) P=0.004	0.2296 (50) P=0.109

Table 5.18 (continued)

	Sentence Verification				Reading Span	
	True Affirm.	True Neg.	False Affirm.	False Neg.	Total Correct	Achieve. Level
Logical Reasoning	0.0424 (55) P=0.759	-0.2931* (55) P=0.030	-0.0531 (55) P=0.700	-0.3335* (55) P=0.013	0.3331* (49) P=0.019	0.2189 (49) P=0.131
Inference	0.0723 (55) P=0.600	0.0362 (55) P=0.793	0.0257 (55) P=0.852	-0.1487 (55) P=0.278	0.2508+ (49) P=0.082	0.1659 (49) P=0.255
Word Recognition						
Assoc. Words	0.0357 (56) P=0.794	0.1538 (56) P=0.258	0.0697 (56) P=0.610	0.1977 (56) P=0.144	-0.1973 (50) P=0.170	-0.0272 (50) P=0.851
Unassoc. Words	0.0422 (56) P=0.757	0.1612 (56) P=0.235	0.1860 (56) P=0.170	0.2364+ (56) P=0.079	-0.1903 (50) P=0.186	-0.0047 (50) P=0.974
Word-Nonword	0.0401 (55) P=0.771	0.2207 (55) P=0.105	0.1327 (55) P=0.334	0.1701 (55) P=0.214	-0.0191 (49) P=0.857	0.0652 (49) P=0.656
Two Nonwords	0.0153 (56) P=0.911	0.1563 (56) P=0.250	0.0879 (56) P=0.519	0.2179 (56) P=0.107	-0.1322 (50) P=0.360	0.0096 (50) P=0.947
Sentence Verification						
True Affirm.	1.0000 (56) P=*****	0.6367* (56) P=0.000	0.6157* (56) P=0.000	0.6593* (56) P=0.000	-0.1661 (50) P=0.249	-0.2580+ (50) P=0.070
True Neg.	0.6367* (56) P=0.000	1.0000 (56) P=*****	0.6358* (56) P=0.000	0.7544* (56) P=0.000	-0.1420 (50) P=0.325	-0.1290 (50) P=0.372
False Affirm.	0.6157* (56) P=0.000	0.6358* (56) P=0.000	1.0000 (56) P=*****	0.6796* (56) P=0.000	-0.0040 (50) P=0.978	-0.0578 (50) P=0.690
False Neg.	0.6593* (56) P=0.000	0.7544* (56) P=0.000	0.6796* (56) P=0.000	1.0000 (56) P=*****	-0.2008 (50) P=0.162	-0.2086 (50) P=0.146

Table 5.18 (continued)

	Sentence Verification				Reading Span	
Reading Span	True Affirm.	True Neg.	False Affirm.	False Neg.	Total Correct	Achieve. Level
Total Correct	-0.1661 (50) P=0.249	-0.1420 (50) P=0.325	-0.0040 (50) P=0.978	-0.2008 (50) P=0.162	1.0000 (50) P=*****	0.8085 * (50) P=0.000
Achieve. Level	-0.2580 + (50) P=0.070	-0.1290 (50) P=0.372	-0.0578 (50) P=0.690	-0.2086 (50) P=0.146	0.8085 * (50) P=0.000	1.0000 (50) P=*****

(COEFFICIENT / (CASES) / SIGNIFICANCE)

References

Carpenter, P., & Just, M. Sentence comprehension: A psycholinguistic processing model of verification. Psychological Review, 1975, 82, 45-73.

Daneman, M., & Carpenter, P. Individual differences in working memory and reading. Journal of Verbal Learning and Verbal Behavior, 1980, 19, 450-466.

Hunt, E. B., & MacLeod, C. M. The sentence-verification paradigm: A case study of two conflicting approaches to individual differences. Intelligence, 1978, 2, 129-144.

Johnson-Laird, P., & Steedman, M. The psychology of syllogisms. Cognitive Psychology, 1978, 10, 64-99.

MacLeod, C. M., Hunt, E. B., & Mathews, N. N. Individual differences in the verification of sentence-picture relationships. Journal of Verbal Learning and Verbal Behavior, 1978, 17, 493-507.

Chapter 6

Discussion

Major Findings and Patterns of Results

Previous cognitive research in the area of bilingualism suggests that problem solving is less efficient and at times less accurate in the less familiar language of bilinguals. However, apart from isolated research studies and research on the organization of bilinguals' semantic memory, little research has incorporated existing psycholinguist theory and psycholinguistic research paradigms in the investigation of the cognitive processing of bilinguals in each of their languages. As proposed in Chapter Two of the present report, we need to conceptualize the influence of bilingualism on cognitive functioning in terms of hypotheses about how language is utilized in specific problem solving situations.In the present research project we investigated bilinguals' processing and problem solving ability on a set of elementary cognitive and reasoning tasks previously studied in the monolingual psycholinguistic research literature. Each of the major areas of research in the present project and its findings is now overviewed and interpreted.

Reading and Language Proficiency Characteristics of Subjects. The 57 Mexican American subjects of the present study demonstrated greater reading ability in English than in Spanish as reflected by scores on parallel advanced reading comprehension tests administered in each language. Students' answers to a background questionnaire indicated that students judged that they were more competent in English than in Spanish in all of the modalities of language use: oral comprehension, speaking, reading and writing. The fact that students were more proficient in English than in Spanish comes as no surprise as these students were enrolled in a major Ivy League university with high admission standards. Almost all students had received their entire education in English, and hence their proficiency in Spanish was not cultivated through their formal schooling. Given this language profile it was hypothesized that subjects would perform more efficiently and accurately on elementary cognitive and logical reasoning tasks in English than on similar tasks in Spanish.

Elementary Cognitive Task Performance. The results of the Word Recognition Task indicated that similiar cognitive processes were operating in the recognition of graphemic strings as words on both the Spanish and English version of the task. A semantic priming effect occurred in both Spanish and English. Hypothetically, when a word is processed, memory for words with related meaning is also activated resulting in faster recognition of associated word pairs than unassociated word pairs. This effect was evident in both English and Spanish in the present study. Subjects were also slower in recognizing nonword and word-nonword pairs than word pairs in each language. These findings, along with findings of previous research discussed in Chapter Two, suggest that word recognition in bilinguals activates a memory representation for the concepts underlying words that operates in a very similar fashion across languages. Processing speed in word recognition was faster in English than in Spanish, though the reason for this difference may have been related to morphological differences between Spanish and English as well as to greater proficiency in English.

Performance measures on the Sentence Verification Task indicated that subjects tended to encode the meaning of simple affirmative and negative sentences in a similar way regardless of the language in which sentences were stated. Subjects' latency in deciding whether sentences were true of pictoral images was similar across languages for affirmative and negative sentences, for true and false sentence-picture pairs, and for the same preposition embodied in sentence forms. One exception to this pattern suggested that subjects'processing may have been different in Spanish and in English for negative sentences that were a true representation of the pictoral images. Subjects' performance in Spanish appeared to be faster for negative sentences than in English. Since English versions of tasks were always presented first, a practice effect might have led to somewhat speedier performance in Spanish than in English for negative form sentences.

The results of the Reading Span Task indicated that there was very little difference in memory span for words occurring in Spanish sentences as opposed to English sentences. There was evidence of only a slightly larger memory span for English words. This result is somewhat surprising given that subjects manifested significantly greater general reading proficiency in English than in Spanish.

The performance data on elementary cognitive tasks thus suggested that subjects performed with equal accuracy under similar task conditions in both Spanish and English. Processing speed on the Word Recognition Task was faster in English than in Spanish. Some evidence of slower processing speed in English emerged under one set of task conditionsin the Sentence Verification Task.

Logical Reasoning Task Performance. It could be argued that problem complexity might be a critical factor in distinguishing the degree to which language proficiency might affect problem solving performance. Subjects' performance on three logical reasoning tasks in Spanish and English was examined. In the most important task, the Syllogisms Task, subjects were presented a set of 96 syllogism premise pairs on two occasions in each language. The mood and figure of premises replicated a task design previously utilized in an experiment by Johnson-Laird and Steedman (1978). It was hypothesized that the theoretical model of syllogism performance specified by Johnson-Laird and Steedman and used to explain their data would be upheld in the present study. The results of the present study did indeed uphold most of the major predictions made by the Johnson-Laird and Steedman theory and it did replicate most major findings of the previous Johnson-Laird and Steedman study, though there were some notable exceptions.

Accuracy rates in the solution of the same syllogism problems in the present study were highly similar across languages and across sessions. The high consistency in subjects' performance is consistent which the hypothesis that subjects interpreted syllogism problems in a similar fashion and that they followed similar processes in syllogism solution. However, the accuracy rates were noticably lower in the present study than in the Johnson-Laird and Steedman study, especially for problems involving two particular premises (i.e., Moods II, IO, OI, & OO) or two negative premises (i.e., Moods EE, OE, EO, & OO).

One important difference in performance in Spanish and English emerged. Solution of syllogism problems was significantly faster in English than in Spanish. This difference in speed of solution was not related to accuracy of performance.

The present study replicated the finding that the Figure (i.e., order of mention of predicates in premises) of syllogism premise pairs influences or biases the order in which predicates are produced in conclusions. This bias effect was upheld and occurred at a very similar frequency for both Spanish and English versions of syllogism problems. Time required to solve syllogism problems did not appear to be related to occurrence of the bias effect.

Johnson-Laird's and Steedman's (1978) analogical theory of syllogistic reasoning makes five predictions that go beyond the general results reported thus far. The present study produced results supporting four out of the five predictions made by the analogical theory of syllogistic reasoning. These results were consistent across Spanish and English forms of syllogism presentation and across the two occasions in which syllogisms were presented in each language.

One limitation in Johnson-Laird's and Steedman's theory which became apparent was that it is better at accounting for the solution of syllogisms with valid conclusions than syllogisms with no valid conclusions. It may be that some persons possess shortcut rules useful for quickly detecting the occurrence of syllogisms with no valid conclusions. While Johnson-Laird and Steedman recognized the existence of such "shortcuts," they were not fully incorporated into the theory.

Overall the Syllogisms Task data of the present study suggests that bilinguals represent and solve such problems in the same manner regardless of language in which the syllogisms are stated. However, language proficiency does appear to affect the speed with which syllogisms are solved. In the present study subjects solved syllogism problems significantly faster in English than in Spanish. Further research is needed in order to learn the extent to which the difference in solution speed across languages extends beyond difference in speed of encoding syllogism premises when they are first read.

Subjects' performance on two pencil and paper tests of reasoning in Spanish and English was somewhat inconsistent. Data from the Inference Test showed that subjects performed better in English than in Spanish, while the converse was true for data from the Logical Reasoning Test. These test data are hard to interpret. Performance may have been influenced by practice effects--English versions of tests were always administered first and by limitations in the internal consistency reliability of the tests. The number of problems on the Syllogism Task and the high degree of control for problem structure on the Syllogisms Task suggests that this task was a much more valid and sensitive measure of subjects' reasoning skills in Spanish and English than either of the two pencil and paper reasoning tests.

Relationships Among Tasks. In the initial design of the present study it was expected that there would be statistically significant associations between measures of reading comprehension, reasoning and elementary cognitive tasks and measures of performance on the Syllogisms Task. It was hypothesized that these relationships would be stronger in Spanish than in English since proficiency in Spanish was more likely to limit subjects' Syllogisms Task performance in Spanish given the subjects' bilingualism profile.

Some significant correlations were found between reading test scores, scores on pencil and paper tests of reasoning and performance measures of accuracy and speed on the Syllogisms Task. Overall correlations between scores on tests of reading and reasoning tended to be stronger for the accuracy measures on the English versions of the Syllogisms Task and for processing time measures on the Spanish version of Syllogisms Task.

Directions for Further Research

Implications from the present project. The focus of the present project was on understanding how the language of problem presentation might affect performance on a variety of cognitive tasks. The results of this study indicate that bilingual subjects with college-level skills in English are capable of performing elementary cognitive tasks and solving more complex logical problems in much the same way regardless of the language in which the tasks are presented. Furthermore, these results support psycholinguistic models of performance for the tasks investigated: bilingual subjects' performance in both languages paralleled the performance of monolingual subjects on a variety of the tasks.

The detailed psycholinguistic models of task performance applied in this study permitted isolation of performance variables that were sensitive to the central experimental manipulation, language of problem presentation. In the present project performance was often slower in the less familiar language but not necessarily less accurate. Furthermore, the patterns of relative processing time across task conditions was similar for the two languages although processing time differed overall between the two languages.

In general, it seems that the more actively and deeply language must be processed in problem solving, the more likely it is that processing time will be longer in the less familiar language. While slower processing in a less familiar language is most evident at the input stage of problem solving, when subjects first comprehened a problem, the full effect of processing information in a less familiar language may or may not affect further problem solving performance. Some limited evidence emerged in the present study suggesting that bilinguals might adopt different problem solving strategies for verifying negative form sentences in Spanish and in English; this evidence, however, is not definitive and is in need of further research.

A possibility exists that the similarity of the results for English and Spanish in the present study were influenced by Spanish to English translation strategies. This kind of hypothesis might account for the occasionally slower performance latencies in Spanish. Further research is needed on this question. Some data of the present study would not tend to support this hypothesis, though individual differences in language proficiency and problem solving strategies might lead some subjects to systematically rely on translation. For example, data from the Reading Span Task suggested that subjects' memory span for words in sentences was nearly equivalent in Spanish and English. Utilization of a translation strategy in performance of the Spanish Version

Reading Span Task would seem to have placed a heavy burden on subjects that should affected their memory performance in Spanish . This is a plausible hypothesis since subjects were required to read words aloud in Spanish (and not English) and since they were required to write down what they remembered in Spanish and not in English.

Attention is now turned to some implications of the present projects for further research. Special attention is given to the idea of training and assessment of cognitive skills in bilinguals and to the study of more complicated problem solving which might demonstrate cultural as well as linguistic influences on problem solving.

Needed Research

In order to aid cognitive assessment and cognitive training of bilinguals, bilingual cognitive research must take an integral, programmatic approach. Subjects' language familiarity and proficiency must be analyzed along with the linguistic and non-linguistic demands of problem solving tasks and research studies must be capable of describing how language familiarity specifically affects problem solving. Also, studies of bilinguals should always include information about particular profiles of bilingualism present in subjects. Bilinguals with knowledge of the same two language systems are not all alike in terms of the degree and type of familiarity they have for two language systems. Equal familiarity across all domains of language use is extremely rare. Our ability to specify how language familiarity affects problem solving in a less familiar versus more familiar language depends on an accurate assessment of dual language capabilities.

Ideally, language capabilities should be assessed at two different levels. General proficiency in each of two language systems may be assessed by means of integrative proficiency tests that require manipulation of multiple language structures and different modalities of language use. Results of such tests are useful in describing the global abilities of persons in each language; such results may further be used in establishing hypotheses about the impact of gross differences in proficiency on problem solving. A second level of language proficiency in need of assessment is ability to utilize the particular language modalities and language codes that are involved in criterion problem solving tasks. This level of assesment is important in accounting for explicit ways in which language familiarity may affect problem solving. With appropriate experimental designs, measurement of this sort of focused language proficiency can be accomplished as a part of the examination of performance on criterion problem solving tasks involving language.

A second procedure for improving bilingualism research from an information-processing perspective is to develop a task analysis model of performance on criterion problem solving tasks. An earlier chapter of this report suggested the valuable strategy of partitioning an account of problem solving on tasks into problem input, conceptual representation and solution of a problem, and verbal (or other) output of problem solving behavior. As discussed below even more refined analysis of task demands and required cognitive skills are needed.

Well known experiments in psycholinguistics involving word recognition and sentence verification, as in the present project, can be used to study how language familiarity may or may not affect problem solving performance across two language systems. Many experimental paradigms in cognitive research have a detailed account of information processing in carrying out tasks. Performance of bilinguals in each of their two language systems on criterion information-processing tasks can be used to isolate differences and similarities in problem solving behavior across two language systems. Although discovery of such effects is interesting theoretically in its own right--e.g., verification of the validity of existing monolingual-based theories, it may also be useful in generating performed measures that are helpful in studying bilinguals' performance on more complex tasks that share some processing requirements with the more elementary experimental tasks. As the following discussion indicates, we first need to improve the sophistication of models of bilinguals' cognitive processing.

Further bilingualism research on highly structured cognitive tasks such as the ones investigated in the present project would benefit from more precise research designs. Cognitive components research (Sternberg, 1982) seems suited for such research in the future because it permits specification of complex information processing components which may be layered and interconnected at different levels of problem solving performance. A framework for utilization of cognitive components in problem solving such as that provided by Sternberg (1982) is useful because it partitions information procesing in a manner accounting for: higher-order control processes in problem solving (metacomponents); processes used in the execution of problem solving and reasoning strategies (performance components); processes used in learning how to solve problems (acquisition components); processes used in retrieving previously stored knowledge (retention components); and processes used in transferring skills from one problem solving task to another (transfer components). Apart from the improved theoretical detail provided by a cognitive components approach, the response time and choice performance measures used in cognitive components are highly sensitive to within individual as well as to across individual differences in problems. Thus the cognitive components approach would appear highly valuable in the study of cognitive effects of bilingualism albeit that we might be able to at best investigate operation of one or two components in a single study.

High level problem solving tasks involving rich semantic interpretation of problem materials, inference-making, and extensive, flexible use of metacomponents in thinking are not usually amenable to simple information-processing modeling such as undertaken in the preent project. Nonetheless, language familiarity effects on problem solving on such tasks may be assessed if appropriate task analysis and problem solving models are used. Most interesting and complex problem solving tasks require extended semantic information processing, affecting how problem solving information is interpreted, represented, and manipulated. One important question for future research is whether bilinguals are capable of adopting and manipulating as sophisticated a representation of very complex, semantically rich problems when problems are input in their less familiar rather than more familiar language. Truly complex problems, e.g., explaining cause-effect relationships would be much more complex than the tasks investigated in the present project. Evidence that bilinguals are capable of more sophisticated problem solving in one language versus another for the same types of semantically rich and complex problems would lead to further questions. Going beyond evidence of differences in problem representation and resulting problem solving performance, we should be able to conduct research to tell us how language familiarity specifically resulted in differences in problem representation and solution. As mentioned below, cultural and social background factors may interact with language familairity to affect problem solving when problems are complex and semantically rich.

The present project suggests that more frequent use of within subject research design may enhance bilingual research. Within subject designs allow us to compare individual bilinguals' problem solving efficiency in one language versus another. This helps control for background and personal variables, which would be difficult if not impossible to control for in group-comparison research designs. As such, the reliability and precision of data--such as reaction times--are enhanced by use of designs comparing within-subject performance across two languages. One significant problem which emerges, however, is the need to control for practice effects which are induced by the order in which tasks are presented in two languages. Designs of studies should counterbalance order of task presentation in two languages, so that practice affects may be removed from other effects via analysis of variance. This procedure was not possible to follow in the present project.

The question of how bilingualism research might be made useful for cognitive training is not premature altogether. An interesting example of a program for cognitive training that could be implemented with bilinguals is given by the reading research of Frederiksen (Frederiksen, Warren, Gillote, & Weaver, 1982). The objective of the Frederiksen work is to assess and train monolinguals in word decoding efficiency at different levels of text understanding. Training is administered via microcomputer games that challenge subjects to sharpen and speed up their ability to detect letter clusters in target words, to pronounce words quickly and accurately, and to detect appropriateness of word meaning in the context of sentences. Some of the results of this cognitive research training suggest that training is effective in improving skills at each level of decoding and sentence processing examined and that training may improve general reading skills outside of training contexts.

It is conceivable that a program of training such as that pursued by Frderiksen could be extended productively to bilingual trainees. The procedures proposed by Frederiksen might be used to teach non-English native speakers how to recognize and understand words more effectively in English. The particular letter and word stimuli chosen for training could be selected so as to sharpen discrimination and speed of discrimination of word features in English which otherwise might be confused with word features stemming from knowledge of a particular non-English language.

In the case where bilinguals are not skilled readers in their more familiar language, training of reading skills in the more familiar language may be used as a procedure to prepare for training of reading in the less familiar language. This procedure would prove feasible if two language systems were enough alike to expect transfer of reading skills across languages. A perfect match of language structures across languages would not be necessary, nor could it be expected. Some of the cognitive component skills required in reading may be very general and not language specific. For example, learning how to guide visual movements in reading in one language may rely on skills which could be used in guiding visual processes in reading another language with similar orthography. Differences in languages and their printed format could, of course, affect the degree of transfer from reading in one language to reading in another language. Nonetheless, strategies such as the one mentioned may be flexible and transferable across languages, since they are in service of some of the higher level components of reading--such as searching for a completed idea in a given grammatical unit. Certainly we would expect the latter sort of general component to transfer across languages with similar grammatical structures.

The discussion of training of reading skills in a less familiar language is an exciting prospect. It is concrete in that we have an existing program, such as that of Frederiksen, that might be modified for use with bilinguals. Secondly, the kind of training application under consideration is exciting theoretically in that it would advance our knowledge of cognitive and linguistic skills as they interact with bilingualism. Lastly, but not least important, the kind of training application cited has practical value, given the schooling problems faced in the U. S. by persons from bilingual backgrounds.

In closing this chapter, it is essential to mention a critical topic that cannot be thoroughly discussed here, but that merits attention elsewhere. This topic is the role of cultural modes of thought and language use that may be associated with the occurrence of bilingualism. This complex topic has not received very much attention from cognitive psychologists or from bilingualism researchers. Cross-cultural cognitive psychologists, however, such as Scribner (1979) and Scribner and Cole (1981) suggest that there are very intimate connections between the cultural organization of life and modes of thought and problem solving. One of the points emerging from research in this area is that formal schooling often seems to allow persons to develop skills in abstraction needed for problem solving in problem domains relying on literacy. At present, information-processing psychology by and large has yet to incorporate such research findings on connections between language and thought. There are some notable exceptions, such as the study of Tannen (1979) on cognitive schemata utilized by Greek American women in interpreting narrative description of filmed episodes. Another exception is the research of Steffensen, Jogdeo, and Anderson (Note 1) on cultural influences on the recall of event narratives. Topics such as the foregoing represent exciting areas for research on language and cognition that have just begun to be explored.

Reference Note

Steffensen, M. S., Jogdeo, C., & Anderson, R. C. A cross-cultural perspective on reading comprehension. Technical Report No. 97. Champaign, IL: Center for the Study of Reading, iversity of Illinois, July 1978.

References

Frederiksen, J., Warren, B., Gillote, H., & Weaver, P. The name of the game is literacy. CCN, May/June 1982, 23-27.

Johnson-Laird, P., & Steedman, M. The psychology of syllogisms. Cognitive Psychology, 1978, 10, 64-99.

Scribner, S., & Cole, M. The psychology of literacy. Cambridge, MA: Harvard University, 1981.

Sternberg, R. Reasoning, problem solving, and intelligence. In R. Sternberg (Ed.), Handbook of human intelligence. New York: Cambridge University Press, 1982.

Tannen, D. What's in a frame?: Surface evidence for underlying expectations. In R. O. Freedle (Ed.), New directions in discourse processing. Norwood, NJ: Ablex, 1979, 137-181.

APPENDIX A

LOGICAL REASONING TESTS
COVER PAGES OF INSTRUMENTS

Identification No. ____

INFERENCE TEST -- RL-3

In each item on this test you will be given one or two statements such as you might see in newspapers or popular magazines. The statements are followed by various conclusions which some people might draw from them. In each case, decide which conclusion can be drawn from the statement(s) without assuming anything in addition to the information given in the statement(s). There is only one correct conclusion.

Mark your answer by putting a circle around the number in front of the conclusion that you select.

Consider the following sample item:

Bill, a member of the basketball team, is 6 feet, 2 inches tall and weighs 195 pounds. To qualify for the team, a person must be at least 5 feet, 10 inches tall.

1-The larger a man is, the better basketball player he is.
2-Basketball players are often underweight.
3-Some players on the team are more than 6 feet tall.
4-Bill is larger than the average man.
5-The best basketball players come from the ranks of larger-than-average men.

Only conclusion 3 may be drawn without assuming that you have information or knowledge beyond what the statements give. The statements say nothing about how good different players are, nothing about whether they are underweight, and nothing about average or taller-than-average men.

Your score on this test will be the number marked correctly minus some fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the answer choices as wrong.

You will have 6 minutes for this test. Be sure to do all the items if you have time. When you have finished, STOP.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Copyright c 1962, 1975 by Educational Testing Service. All rights reserved.

Núm. de Identificación ___

PRUEBA DE INFERENCIA--RL-3, Forma, S2

Cada pregunta de esta prueba incluye una o dos declaraciones similares a las que se encuentran en periódicos o revistas populares. Las declaraciones son seguidas por varias conclusiones que algunas gentes podrán derivar de ellas. En cada caso, decida cual conclusión puede ser derivada de la(s) declaración(es) asumiendo nada adicional a la información provista por la(s) declaración(es).

Encierre en un círculo el número de la respuesta que seleccionó.

Considere la siguiente pregunta como ejemplo:

> Juan, miembro del equipo de baloncesto, de 6 pies, 2 pulgadas y pesa 195 libras. Para calificar en el equipo, una persona debe tener, por lo menos, 5 pies 10 pulgadas de altura.

Respuesta:
1- Entre mas alto sea un hombre, mejor jugador de baloncesto es.
2- Los jugadores de baloncesto frequentemente son bajos de peso.
3- Algunos jugadores del equipo miden más de 6 pies.
4- Juan es más grande que el hombre promedio.
5- Los mejores jugadores de baloncesto provienen de los rangos de hombres más grandes que el promedio.

Sólo la conclusión 3 puede ser derivada sin asumir que usted tiene información o conocimiento adicional al que dan las declaraciones. Las declaraciones no dicen nada acerca de lo bueno que son diferentes jugadores, nada acerca de si ellos son bajos de peso, y nada acerca de los hombres de altura promedio o más altos que el promedio.

Su puntaje en esta prueba será el número marcado correctamente menos alguna fracción del número marcado incorrectamente. Por lo tanto, no será ventajoso para usted adivinar la respuesta a menos que sea capaz de eliminar una o más de las selecciones de las respuestas como incorrectas.

Tendrá 6 minutos para cumplir esta prueba.

NO PASE A LA SIGUIENTE PÁGINA HASTA QUE SE LE PIDA HAGERLO

Logical Reasoning Test, English

INSTRUCTIONS AND EXAMPLES

Each item consists of two statements that are followed by four conclusions. It will be your task to examine each pair of statements, and to decide which one of the four given conclusions is the correct one.

Here is an example:

No birds are insects.
All swallows are birds.

Therefore:
[✓ a.] No swallows are insects.
b. Some birds are not swallows.
c. All birds are swallows.
d. No insects are birds.

Since insects include no birds, and birds include all swallows, conclusion "a" is correct. You would record this on your answer sheet by circling the letter of the correct answer as has been done above.

Try another example:

All loans are profitable.
Some loans are investments.

Therefore:
a. All profitable things are investments.
b. Some profitable things are loans.
[✓ c.] Some investments are profitable.
d. Some investments are not profitable.

Investments include some loans, and all loans are profitable. Therefore, conclusion "c" is correct. You would record this answer by circling the letter "c" as shown above.

Notice that a correct conclusion is derived from both statements, and from those statements only. A correct conclusion is not just a repetition of the contents of one of the statements. A correct conclusion is not based on information other than that supplied by the given statements.

Copyright 1955 Sheridan Supply Company, appearing in French, Ekstrom and Price, Educational Testing Service (data). Adapted with ETS permission.

Instrucciones y Ejemplos

Cada pregunta consiste de dos declaraciones seguidas por cuatro conclusiones. Su tarea consistirá en examinar cada par de delcaraciones y decidir cual de las cuatro conclusiones es la correcta.

Este es un ejemplo:

Ningun pájaro es insecto. Todas las golondrinas son pájaros.

[✓ a.] Ninguna golondrina es insecto.
b. Algunos pájaros no son golondrinas.
c. Todos los pájaros son golondrinas.
d. Ningun insecto es pájaro.

Puesto que los insectos no incluyen a los pájaros, y los pájaros incluyen a todas las golondrinas, la conclusión "a" es la correcta.

Practique con otro ejemplo:

Todos los prestamos son provechosos. Algunos prestamos son inversiones.

Por lo tanto:
a. Todas las cosas provechosas son inversiones.
b. Algunas cosas provechosas son préstamos.
[✓ c.] Algunas inversiones son provechosas.
d. Algunas inversiones no son provechosas.

Las inversiones incluyen a algunos préstamos, y todos los préstamos son provechosos. Por lo tanto, la conclusión "c" es la correcta.

Nótese que una conclusión correcta se deriva de ambas declaraciones, y de esos enunciados solamente. Una conclusión correcta se basa únicamente en la información proporcionada por las declaraciones dadas.

APPENDIX B

SENTENCES USED IN THE READING SPAN TASK

SPANISH SENTENCES 10/14/81

1. Muchas veces los niños muy pequeños sienten temor cuando oyen un ruido muy fuerte.

2. Compran muchos muebles y otras cosas para su casa nueva y muy pronto deben mucho dinero.

3. Le pidío que llenara una bolsa con billetes de veinte y cinquenta dólares.

4. El establecimiento abrirá sus puertas ofreciendo a sus primeros clientes premios y regalos.

5. Las lluvias frequentes de los últimos dias causaron inundaciones serias en todo el valle.

6. Cuando las personas están gordas muchas veces se ponen a régimen para adelgazar.

7. El descubrimiento del nuevo mundo es parte de la historia de sólo unos cuantos paises.

8. No debe haber deportes en las escuelas porque necesitamos el dinero para otras cosas.

9. Cuando no esta trabajando, mucha gente descansa viendo televisión o platicando con amigos.

10. La selección de una carrera es una decisión de gran importancia para todos los jóvenes.

11. Ahora que los jóvenes saben cuánto peligro trae el cigarro, es possible que no fumen tanto.

12. Todos los paises tratan de
destruir el contraste entre la
vida de pobres y de ricos.

13. Las mujeres altas y fuertes no
eran femeninas, según la imágen
típica de la mujer.

14. La vida es corta y por lo
tanto hay que aprovecharla en
cuanta forma se pueda.

15. Roberto se levantó, se vistió,
se comió nueve tortillas y
se fue a su trabajo.

16. Había llegado a la sección de
joyas y me sentía como una
reina en su palacio.

17. Por tal motivo me pidió algo
de dinero para que al menos
pudiera comer un poco.

18. Traía un dolor de cabeza muy
fuerte y pensaba que si dormía
se sentiría mejor.

19. Le preguntó que si iba a leer
un cuento, aunque el había
dicho que no quería.

20. Yo sé que estas ocupado,
pero mi automóvil está listo
para salir ahora mismo.

21. Yo acabo de escribir una novela
pero Jaime ya acabó de escribir
la suya hace tiempo.

22. El clima era una causa de la
sencillez de la gente de esa
isla tan remota.

23. Siempre hacía calor y las brisas
que soplaban hacían a uno
tener mucho sueño.

24. Eran los parientes de Yolanda,
que la miraban con un miedo
que no tenía límites.

25. Más que el disparo la angustia
de la voz le había disipado
todas sus sospehas.

26. Yo pienso que es muy importante
que una persona chicana o
puertorriqueña sepa el español.

27. De todas las cosas que enseñaste
la que más gusta viene siendo
áquella mostrada finalmente.

28. Para leer bien es necessario
poder reconocer la idea principal
de cada párrafo en una lectura.

29. El problema más serio para muchos
adolescentes es el decidir que
quieren hacer con su vida.

30. Sin embargo, al terminar los
estudios secundarios, los jóvenes
se ven forzados a decidir.

31. Hay que trabajar para ganar
dinero y tienen que entrenarse
bien para poder hacerlo.

32. La guerra, entre los aztecas,
tenía como principal objetivo
obtener hombres para el sacrificio.

33. En éste capítulo presentamos
dos composiciones escritas por
niños sobre temas muy distintos.

34. La pobreza es la falta de dinero
o de suficientes recursos que
se necesitan para vivir.

35. A la mayoría de la gente
pobre le falta esa educación
y esa habilidad.

36. Cuando el chico se equivocó
en el piano entonces todos
sus amigos se burlaron.

37. Ya están empezando a crecer
las semillas de tomate que
plantamos hace unos meses.

38. No quiero que juegues con
ese niño porque es muy descortéz
y tambien muy brusco.

39. Quiero que me digas porqué
estan matando tanta gente
en aquel pais.

40. Algunos usan la droga para
calmarse los nervios sin saber que
les está afectando la salud.

41. El gobernador anuncío el nombre
de su nuevo ayudante el jueves
por la tarde.

42. Además, sólo te estarás
cerrando puertas que algún día
quizás quieras abrir nuevamente.

43. Si lo que sientes son deseos
de sentarte a conversar con
un viejo amigo, hazlo.

44. Una buena idea para volver a
'entrar en circulación' es
dar una fiesta en tu casa.

45. Si aún eres muy jóven, es
posible que no estés segura
de lo que quieres.

46. Todo esto sigue siendo interesante
para el que busca entretenimiento
mas que resultados prácticos.

47. El año pasado, este muchacho
obtenío las mejores calificaciones
de toda su clase.

48. Los policías descubrieron un
pasaje que estaba debajo de la
tierra, por dónde salieron ellos.

49. Se llama Francisco pero su
sobrenombre es 'el relámpago'
porque corre muy fuerte.

50. Era un sábado como a las
cuatro de la tarde y yo
estaba en mi jardín.

51. Muchas veces la gente se ríe
cuando ve que alguna persona
se resbala en la calle.

52. En este país se piensa que
todos tienen derecho a sus

creencias religiosas.

53. Durante el crecimiento es muy
importante que los niños
no tengan deficiencias vitamínicas.

54. Juan no puede concentrarse en
sus estudios y a la misma
vez ver television.

55. Cuando María terminó con su
novio, dijo que sólo tenía
una gran indiferencia por él.

56. Hubo un incidente desagradable
en el restaurante entre dos
hombres y una mesera.

57. Al principio la niña no quería
participar en los juegos de los
otros niños.

58. El español casi no tiene
combinaciones de dos letras
diferentes que sólo dan un sonido.

59. A lo mejor se sienten mal y
después no se acuerdan
de nada sucedido.

60. No es lo mismo, por ejemplo,
leer un periódico que leer
una novela de buena calidad.

61. Las decisiones las hace él
y si salen mal le echa la
culpa a su esposa.

62. Golpear a una mujer es lo más
bajo en que puede caer un
hombre de reputación.

63. Se dice que las mujeres sólo
valen lo que vale el hombre
con quien se casan.

64. Para realizar nuestros sueños
de algún día ser millionarios
es possible que tengamos que luchar.

65. Este país lanzó un cohete al
espacio por primera vez hace
más de diéz años.

66. La iglesia se encuentra en un
extremo de la ciudad y mi
apartamento en el otro.

67. Siento mucho que a Javier
no le guste la camisa que
le compré el otro día.

68. Estos individuos deben estar
encarcelados para que dejen de
dar batalla a la gente decente.

69. No hay nada que me guste tanto
cómo sentarme afuera a ver
bajar el sol.

70. A mi me gustan los lugares
elegantes y que la gente tenga
que vestirse bien.

* * * * * * * * * * *

ENGLISH SENTENCES 10/16/81

1. To be involved in sports was all that truly mattered to the young athlete.

2. A cheerful person may have many cares but has learned how to deal with them.

3. He fastened the gilded buttons on his jacket and adjusted his white cotton wig.

4. Some people in show business come up with eye-catching methods of promoting themselves.

5. Washing carpets is a summer ritual with people who live near the sea or a lake.

6. The second book she bought, more explicit than the first, caused him to blush.

7. We can't give our children the future, but we can strive to make it secure.

8. Except for a few minor engine alterations, the cars look and run like standard models.

9. If the business succeeds, they will each get five percent of the net profits.

10. Our friends' teenage daughter excitedly announced her first invitation to go on a date.

11. The sun was low on the horizon when we began our journey down the dangerous trail.

12. The detectives have not been
able to find a pattern to
the mysterious events.

13. Don proudly drove his shiny
new car to work and parked
it in a public garage.

14. The uniquely delicious flavor
was created in Old New Orleans
almost a century ago.

15. They found themselves staring
at internal cell structures no
one had ever seen before.

16. One thing the past teaches us
is that the future will be
full of surprises.

17. Camping and backpacking are
economical ways for a family
to enjoy a summer vacation.

18. Although the two brothers were
identical twins, in many ways
they were completely different.

19. His job as a lifeguard called
for him to spend many hours
in the hot sun.

20. The drive to the airport took
him twice as long as the flight
to his meeting.

21. By pacing himself in the early
rounds, the boxer was able to
achieve a victory.

22. The family car of the eighties
will be geared to safety and
fuel economy.

23. The dark sky and distant thunder told us a welcome summer storm was on its way.

24. The appearance of the first robin is a sign that spring will soon be here.

25. Summer is the season to enjoy fresh fruits and vegetables grown by local farmers.

26. The large shopping malls have forced many of the smaller stores out of business.

27. It was necessary for the farmers to spray their crops to prevent a disaster.

28. She enjoyed showing her visitors from overseas all the places of interest in the area.

29. The little girl made a wish as she blew out the candles on her birthday cake.

30. The snow storm disrupted the busy holiday traffic, causing many delays for the frustrsted drivers.

31. Doing a jigsaw puzzle on a rainy afternoon is a pleasant way to pass the time.

32. Her trip to the mailbox was rewarded by a letter from an old and dear friend.

33. Their house was filled with interesting items they had collected from various trips.

34. On a cold winter's day coming home to sit before a roaring fire is a pleasure.

35. Due to the lack of water, the firemen were unable to contain the forest fires.

36. She was awakened from a sound sleep by a persistant banging on the front door.

37. She was not allowed to eat for eight hours before having the tests at the hospital.

38. The policeman gave him a ticket for speeding and for going through a red light.

39. He completed his disguise with a large hat, dark glasses and a bushy beard.

40. The propeller driven planes became almost obsolete with the coming of the jet engine.

41. Many of the returning veterans neglected to take advantage of the government benefits.

42. The picnic basket contained salad, rolls, chicken, fruit and a bottle of white wine.

43. By having his personal computer at home, he was able to save both time and money.

44. The strikers refused to back down on their demands for better benefits and wages.

45. The copy was so good that it
was difficult to tell it from
the original.

46. He collected coins and stamps,
hoping that in a few years their
value would increase.

47. Due to inflation and higher
costs they were unable to send
their son to college.

48. The factories were heavily
fined for allowing their waste
to pollute the nearby streams.

49. The seniors put on a very good
show, and the audience loudly
requested an encore.

50. Everyone enjoys receiving mail,
but few people like to sit down
and write letters.

51. The family gathered around the
festive table to share the joys
of the holiday season.

52. The elderly couple found it very
difficult to support themselves
on his meager pension.

53. The waiter was very clumsy and
spilled the hot soup down the
front of his jacket.

54. They had not jogged for a long
time and soon found themselves
out of breath.

55. They were late arriving and
found most of the guests had
already been seated.

56. The trees and shrubs had been stripped bare by an infestation of swarming insects.

57. The hike was long and strenuous, and he discovered his feet were covered with blisters.

58. The air turbulence was severe, and the passengers and crew were glad to alight safely.

59. A large bowl of homemade chicken soup helps warm you up on a cold winter's day.

60. She was unable to concentrate on the magazine while awaiting her turn in the dentist's office.

61. The small country towns and villages whizzed by as he gazed from the train's window.

62. He found the atmosphere of the lounge very relaxing after his hectic day at the office.

63. A bottle containing a message for help was carried to shore by the waves.

64. Her hospital stay was made more pleasant through the kindness of the doctors and nursing staff.

65. The artist could not concentrate on his work when someone was looking over his shoulder.

66. The dishwasher broke down, and the hot soapy water gushed over the kitchen floor.

67. The audience was completely enthralled with the skill of the high wire trapeze artists.

68. The fast lane of a busy highway is a dangerous place to have a flat tire.

69. He was able to sell his bicycle by placing a notice on the bulletin board.

70. There were many applicants for the job, but few had the necessary qualifications.

EXTRA

71. The salary she received from tutoring the slower students helped supplement her income.

72. The table setting with gleaming silver and crystal was enhanced by the soft candlelight.

73. The suns rays filtering through the trees reflected a peaceful image on the still waters.

74. They enjoyed strolling past the ivy covered buildings and through the beautiful flower gardens.

* * * * * * * * * * *

APPENDIX C

SYLLOGISMS TASK MATERIALS

Coding Guide for Answers to the Syllogisms Task

Code	Answer Form Spanish					Answer Form English
1.	Todos	los las	A	son	C	All A are C
2.	Todos	los las	A	no son	C	All A are not C
3.	Algunos	A	son	C		Some A are C
4.	Algunos	A	no son	C		Some A are not C
5.	Ningun(a)	A	es	C		No A are C
6.	Todos	los las	C	son	A	All C are A
7.	Todos	los las	C	no son	A	All are not A
8.	Algunos	C	son	A		Some C are A
9.	Algunos	C	no son	A		Some C are not A
10.	Ningun(a)	C	es	A		No C are A
11.	No conclusion					No conclusion
12.	Another answer					Another answer

ENGLISH (DAY 1)

Correct Responses		
All jockeys are violinists Some violinists are jockeys Some jockeys are violinists	1AA	All jockeys are spendthrifts. All spendthrifts are violinists.
2 Some journalists are anarchists Some anarchists are journalists	1IA	Some journalists are burglars. All burglars are anarchists.
3 Some volunteers are not debutantes	1EA	No debutantes are seamstresses. All seamstresses are volunteers.
4 No valid conclusion	1OA	Some masons are not scholars. All scholars are investors.
5 No valid conclusion	1AI	All sargeants are golfers. Some golfers are archers.
6 No valid conclusion	1II	Some janitors are patients. Some patients are runners.
7 Some librarians are not educators	1EI	No educators are protestors. Some protestors are librarians.
8 No valid conclusion	1OI	Some engravers are not inventors. Some inventors are landlords.
9 No bailiffs are pilots No pilots are bailiffs	1AE	All bailiffs are skiers. No skiers are pilots.
10 Some heroes are not apprentices	1IE	Some heroes are councilmen. No councilmen are aprentices.

Correct Responses

11	No valid conclusion	1EE	No $\overset{A}{\text{barbers}}$ are $\overset{B}{\text{liars}}$. No $\overset{B}{\text{liars}}$ are $\overset{C}{\text{umpires}}$.
12	No valid conclusion	1OE	Some $\overset{A}{\text{playwrights}}$ are not $\overset{B}{\text{cartoonists}}$. No $\overset{B}{\text{cartoonists}}$ are $\overset{C}{\text{sportscasters}}$.
13	No valid conclusion	1AO	All $\overset{A}{\text{balloonists}}$ are $\overset{B}{\text{ventriloquists}}$. Some $\overset{B}{\text{ventriloquists}}$ are not $\overset{C}{\text{collectors}}$.
14	No valid conclusion	1IO	Some $\overset{A}{\text{chemists}}$ are $\overset{B}{\text{leftists}}$. Some $\overset{B}{\text{leftists}}$ are not $\overset{C}{\text{yachtsmen}}$
15	// No valid conclusion	1EO	No $\overset{A}{\text{astronauts}}$ are $\overset{B}{\text{physicists}}$. Some $\overset{B}{\text{physicists}}$ are not $\overset{C}{\text{candidates}}$.
16	No valid conclusion	1OO	Some $\overset{A}{\text{stenographers}}$ are not $\overset{B}{\text{freshmen}}$. Some $\overset{B}{\text{freshmen}}$ are not $\overset{C}{\text{vegetarians}}$.
17	All songwriters are pollsters Some pollsters are songwriters Some songwriters are pollsters	2AA	All $\overset{B}{\text{navigators}}$ are $\overset{A}{\text{pollsters}}$. All $\overset{C}{\text{songwriters}}$ are $\overset{B}{\text{navigators}}$.
18	// No valid conclusion	2IA	Some $\overset{B}{\text{watchmakers}}$ are $\overset{A}{\text{immigrants}}$. All $\overset{C}{\text{contestants}}$ are $\overset{B}{\text{watchmakers}}$.
19	No bicyclists are horsemen No horsemen are bicyclists	2EA	No $\overset{B}{\text{storekeepers}}$ are $\overset{A}{\text{horsemen}}$. All $\overset{C}{\text{bicyclists}}$ are $\overset{B}{\text{storekeepers}}$.
20	No valid conclusion	2OA	Some $\overset{B}{\text{veterinarians}}$ are not $\overset{A}{\text{sunbathers}}$. All $\overset{C}{\text{wrestlers}}$ are $\overset{B}{\text{veterinarians}}$.
21	Some mystics are hypnotists Some hypnotists are mystics	2AI	All $\overset{B}{\text{pacifists}}$ are $\overset{A}{\text{hypnotists}}$. Some $\overset{C}{\text{mystics}}$ are $\overset{B}{\text{pacifists}}$.

Correct Responses

22
'No valid conclusion
2II Some guards are sheriffs.
Some examinees are guards.

23
Some racers are not nudists
2EI No bookdealers are nudists.
Some racers are bookdealers.

24
'No valid conclusion
2OI Some presidents are not visionaries.
Some speakers are presidents.

25
'Some beachcombers are not motorists
2AE All accountants are beachcombers.
No motorists are accountants.

26
Some veterans are not campers
2IE Some architects are veterans.
No campers are architects.

27
'No valid conclusion
2EE No weightlifters are bartenders.
No surfers are weightlifters.

28
'No valid conclusion
2OE Some surgeons are not fencers.
No equestrians are surgeons.

29 2AO ↗ CHU All Southerners are typists.
No valid conclusion Some accordionists are not Southerners.

30
No valid conclusion
2IO Some democrats are auctioneers.
Some sculptors are not democrats.

No valid conclusion 31
2EO No marchers are jewelers.
Some birdwatchers are not marchers.

32
'No valid conclusion
2OO Some moviegoers are not atheists.
Some petitioners are not moviegoers.

Correct Responses

33
3AA
No valid conclusion
All hedonists are comedians.
All mercenaries are comedians.

34
3IA
No valid conclusion
Some opticians are jugglers.
All guitarrists are jugglers.

35
3EA
No conservationists are gamblers
No gamblers are conservationists
Some gamblers are not conservationists
No conservationists are capitalists.
All gamblers are capitalists.

36
3OA
Some enlistees are not survivors
Some enlistees are not missionaries.
All survivors are missionaries.

37
3AI
No valid conclusion
All renters are gourmets.
Some clerks are gourmets.

38
3II
No valid conclusion
Some hermits are marksmen.
Some novelists are marksmen.

39
3EI
Some poets are not stevedores
No stevedores are skydivers.
Some poets are skydivers.

40
3OI
No valid conclusion
Some hecklers are not legionnaires.
Some hitchhikers are legionnaires.

41
3AE
No lobbyists are reservists
No reservists are lobbyists
All lobbyists are aristocrats.
No reservists are aristocrats.

42
3IE
Some historians are not commuters
Some historians are diners.
No commuters are diners.

43
3EE
No valid conclusion
No winners are orators.
No envoys are orators.

Correct Responses

No valid conclusion	44	3OE	Some ushers are not astrologers. No druggists are astrologers.
Some trainees are not wreckers	45	3AO	All wreckers are paupers. Some trainees are not paupers.
No valid conclusion	46	3IO	Some picnickers are organists. Some partygoers are not organists.
No valid conclusion	47	3EO	No technicians are hikers. Some orderlies are not hikers.
No valid conclusion	48	3OO	Some experts are not scapegoats. Some translators are not scapegoats.
Some tyrants are bureaucrats Some bureaucrats are tyrants	49	4AA	All $\overset{B}{\text{eccentrics}}$ are $\overset{A}{\text{tyrants}}$. All $\overset{B}{\text{eccentrics}}$ are $\overset{C}{\text{bureaucrats}}$.
Some woodsmen are bohemians Some bohemians are woodsmen	50	4IA	Some $\overset{B}{\text{coaches}}$ are $\overset{A}{\text{woodsmen}}$. All $\overset{B}{\text{coaches}}$ are $\overset{C}{\text{bohemians}}$.
Some fortunetellers are not vocalists	51	4EA	No $\overset{B}{\text{gymnasts}}$ are $\overset{A}{\text{vocalists}}$. All $\overset{B}{\text{gymnasts}}$ are $\overset{C}{\text{fortunetellers}}$.
Some churchgoers are not roofers	52	4OA	Some $\overset{B}{\text{conventioneers}}$ are $\overset{A}{\text{not}}$ roofers. All $\overset{B}{\text{conventioneers}}$ are $\overset{C}{\text{churchgoers}}$.
Some joggers are bowlers Some bowlers are joggers	53	4AI	All $\overset{B}{\text{stewardesses}}$ are $\overset{A}{\text{joggers}}$. Some $\overset{B}{\text{stewardesses}}$ are $\overset{C}{\text{bowlers}}$.
No valid conclusion	54	4II	Some $\overset{B}{\text{stargazers}}$ are $\overset{A}{\text{yodelers}}$. Some $\overset{B}{\text{stargazers}}$ are $\overset{C}{\text{housewives}}$.

Correct Responses

55	Some tailors are not magicians	4EI	No servicemen are magicians. Some servicemen are tailors.
56	? No valid conclusion	4OI	Some cadets are not drummers. Some cadets are teammates.
57	Some communists are not naturalists	4AE	All spectators are communists. No spectators are naturalists.
58	Some demonstrators are not smugglers	4IE	Some villagers are demonstrators. No villagers are smugglers.
59	No valid conclusion	4EE	No publishers are tycoons. No publishers are geologists.
60	No valid conclusion	4OE	Some performers are not chefs. No performers are sopranos.
61	Some geniuses are not acrobats	4AO	All buglers are geniuses. Some buglers are not acrobats.
62	No valid conclusion	4IO	Some Texans are meteorologists. Some Texans are not bigamists.
63	No valid conclusion	4EO	No tribesmen are captives. Some tribesmen are not explorers.
64	No valid conclusion	4OO	Some disputants are not preachers. Some disputants are not colleagues.

* * * * * * * * *

ENGLISH (DAY 2) Revised

Correct Responses		
All masons are investors Some investors are masons Some masons are investors		A B All masons are scholars. B C All scholars are investors.
Some sargeants are archers Some archers are sargeants	1IA	Some sargeants are golfers. All golfers are archers.
Some runners are not janitors	1EA	No janitors are patients. All patients are runners.
No valid conclusion	1OA	Some jockeys are not spendthrifts. All spendthrifts are violinists.
No valid conclusion	1AI	All journalists are burglars. Some burglars are anarchists.
No valid conclusion	1II	Some debutantes are seamstresses. Some seamstresses are volunteers.
Some landlords are not engravers	1EI	No engravers are inventors. Some inventors are landlords.
No valid conclusion	1OI	Some educators are not protestors. Some protestors are librarians.
No barbers are umpires No umpires are barbers	1AE	All barbers are liars. No liars are umpires.
Some playwrights are not sportscasters	1IE	Some playwrights are cartoonists. No cartoonists are sportscasters.
No valid conclusion	1EE	No bailiffs are skiers. No skiers are pilots.

Correct Responses

No valid conclusion

10E
Some heroes are not councilmen.
No councilmen are aprentices.

2

1AO
All navigators are pollsters.
Some songwriters are not navigators.

No valid conclusion

2IA — 1IO
B A
Some storekeepers are horsemen.
C B
Some bicyclists are not storekeepers.

No valid conclusion

2EO
1EO
B A
No pacifists are hypnotists.
C B
Some mystics are not pacifists.

" No valid conclusion

2OO
1OO
b A
Some bookdealers are not nudists.
C B
Some racers are bookdealers.

" No valid conclusion

2AA
B A
All ventriloquists are baloonists.
C B
All collectors are ventriloquists.

All collectors are baloonists
Some baloonists are collectors
Some collectors are baloonists

2IA
Some beachcombers are accountants.
All motorists are beachcombers.

No valid conclusion

2EA
No leftists are chemists.
All yachtsmen are leftists.

No yachtsmen are chemists
No chemists are yachtsmen

2OA
Some architects are not veterans.
All campers are architects.

No valid conclusion

2AI
All physicists are astronauts.
Some candidates are physicists.

Some candidates are astronauts
Some astronauts are candidates

2II
Some capitalists are conservationists.
Some gamblers are capitalists.

No valid conclusion

Correct Responses		
Some vegetarians are not stenographers	2EI	No freshmen are stenographers. Some vegetarians are freshmen.
No valid conclusion	2OI	Some missionaries are not enlistees. Some survivors are missionaries.
Some immigrants are not contestants	2AE	All watchmakers are immigrants. No contestants are watchmakers.
Some sunbathers are not wrestlers	2IE	Some veterinarians are sunbathers. No wrestlers are veterinarians.
No valid conclusion	2EE	No skydivers are stevedores. No poets are skydivers.
No valid conclusion	2OE	Some aristocrats are not lobbyists. No reservists are aristocrats.
No valid conclusion	2AO	B A All diners are historians. C D Some commuters are not diners.
No valid conclusion	2IO	Some paupers are wreckers. Some trainees are not paupers.
No valid conclusion	2EO	No eccentrics are tyrants. Some bureaucrats are not eccentrics
No valid conclusion	2OO	Some coaches are not woodsmen. Some bohemians are not coaches.
No valid conclusion	3AA	A B All vocalists are gymnasts. C E All fortunetellers are gymnasts.

Correct Responses		
No valid conclusions	3IA	Some roofers are conventioneers. All churchgoers are conventioneers.
No sheriffs are examinees No examinees are sheriffs Some examinees are not sheriffs	3EA	No sheriffs are guards. All examinees are guards.
Some visionaries are not speakers	3OA	Some visionaries are not presidents. All speakers are presidents.
No valid conclusion	3AI	All joggers are stewardesses. Some bowlers are stewardesses.
No valid conclusion	3II	Some magicians are servicemen. Some tailors are servicemen.
Some surfers are not bartenders	3EI	No bartenders are weightlifters. Some surfers are weightlifters.
No valid conclusion	3OI	Some communists are not spectators. Some naturalists are spectators.
No fencers are equestrians No equestrians are fencers	3AE	All fencers are surgeons. No equestrians are surgeons.
Some typists are not accordionists	3IE	Some typists are Southerners. No accordionists are Southerners
No valid conclusion	3EE	No demonstrators are villagers. No smugglers are villagers.
No valid conclusion	3OE	Some geniuses are not buglers. No acrobats are buglers.

Correct Responses

Some sculptors are not auctioneers

3AO
All auctioneers are democrats.
Some sculptors are not democrats.

No valid conclusion

3IO
Some picnickers are organists.
Some partygoers are not organists.

No valid conclusion

3EO
No technicians are hikers.
Some orderlies are not hikers.

No valid conclusion

3OO
Some experts are not scapegoats.
Some translators are not scapegoats.

Some jewelers are birdwatchers
Some bird watchers are jewelers

4AA
B A
All marchers are jewelers.
E C
All marchers are birdwatchers.

Some atheists are petitioners
Some petitioners are atheists

4IA
Some moviegoers are atheists.
All moviegoers are petitioners.

Some mercenaries are not hedonists

4EA
No comedians are hedonists.
All comedians are mercenaries.

Some guitarists are not opticians

4OA
Some jugglers are not opticians.
All jugglers are guitarrists.

Some renters are clerks
Some clerks are renters

4AI
All gourmets are renters.
Some gourmets are clerks.

No valid conclusion

4II
Some stargazers are yodelers.
Some stargazers are housewives.

Some novelists are not hermits

4EI
No marksmen are hermits.
Some marksmen are novelists.

Correct Responses	
No valid conclusion	4OI Some cadets are not drummers. Some cadets are teammates.
Some hecklers are not hitchhikers	4AE All legionnaires are hecklers. No legionnaires are hitchhikers.
Some winners are not envoys	4IE Some orators are winners. No orators are envoys.
No valid conclusion	4EE No publishers are tycoons. No publishers are geologists.
No valid conclusion	4OE Some performers are not chefs. No performers are sopranos.
Some ushers are not druggists	4AO All astrologers are ushers. Some astrologers are not druggists.
No valid conclusion	4IO Some Texans are meteorologists. Some Texans are not bigamists.
No valid conclusion	4EO No tribesmen are captives. Some tribesmen are not explorers.
No valid conclusion	4OO Some disputants are not preachers. Some disputants are not collegues.

* * * * * * * * * * *

SPANISH (DAY 1)

Correct Responses		
Todos los herreros son alumnos Algunos alumnos son herreros Algunos herreros son alumnos	1AA	Todos los herreros son artistas. Todos los artistas son alumnos.
Algunos artesanos son lectores Algunos lectores son artesanos	1IA	Algunos artesanos son divorciados. Todos los divorciados son lectores.
Algunos solteros no son dentistas	1EA	Ningún dentista es cocinero. Todos los cocineros son solteros.
No valid conclusion	1OA	Algunos estudiantes no son deportistas. Todos los deportistas son motociclistas.
No valid conclusion	1AI	Todos los carniceros son futbolistas. Algunos futbolistas son penitentes.
No valid conclusion	1II	Algunos boxeadores son soldadores. Algunos soldadores son albañiles.
Algunos fotógrafos no son payasos	1EI	Ningún payaso es diseñador. Algunos diseñadores son fotógrafos.
No valid conclusion	1OI	Algunos esclavos no son curanderos. Algunos curanderos son mensajeros.
Ningúna cajera es joven. Ningúna joven es cajera.	1AE	Todas las cajeras son telefonistas. Ninguna telefonista es joven.
Algunos paisanos no son músicos	1IE	Algunos paisanos son vecinos. Ningun vecino es músico.
No valid conclusion	1EE	Ningun vaquero es aviador. Ningun aviador es filántropo.

Correct Responses	
No valid conclusion	1OE Algunas madrinas no son enfermeras. Ninguna enfermera es niñera.
No valid conclusion	1AO Todos los panaderos son parientes. Algunos parientes no son escritores.
No valid conclusión	1IO Algunos charros son vagos. Algunos vagos no son jardineros
No valid conclusion	1EO Ningún ministro es matemático. Algunos matemáticos no son abuelos.
No valid conclusion	1OO Algunos farmacistas no son pianistas. Algunos pianistas no son guías.
Todos los abogados son prisioneros Algunos prisioneros son abogados Algunos abogados son prisioneros	2AA Todos los alcaldes son prisioneros. Todos los abogados son alcaldes.
No valid conclusion	2IA Algunas hermanas son cantantes. Todas las meseras son hermanas.
Ningún enano es zapatero Ningún zapatero es enano	2EA Ningún sordo es zapatero. Todos los enanos son sordos.
No valid conclusion	2OA Algunos norteños no son jornaleros. Todos los tabaqueros son norteños.
Algunos marineros son bilingues Algunos bilingues son marineros	2AI Todos los ladrones son bilingües. Algunos marineros son ladrones.
No valid conclusion	2II Algunos campesinos son desertores. Algunos turistas son campesinos.
Algunos choferes no son pescadores	2EI Ningún carpintero es pescador. Algunos choferes son carpinteros.

Correct Responses	
No valid conclusion	2OI Algunos gitanos no son pasajeros. Algunos empleados son gitanos.
Algunos profetas no son extranjeros	2AE Todos los impresores son profetas. Ningún extranjero es impresor.
Algunos borrachos no son limosneros	2IE Algunos sindicalistas son borrachos. Ningún limosnero es sindicalista.
No valid conclusion	2EE Ninguna madrastra es ciega. Ninguna enamorada es madrastra.
No valid conclusion	2OE Algunas bailarinas no son modelos. Ninguna quinceañera es bailarina.
No valid conclusion	2AO Todos los importadores son oficinistas. Algunos pistoleros no son importadores.
No valid conclusion	2IO Algunos bandoleros son viudos. Algunos peloteros no son bandoleros.
No valid conclusion	2EO Ningún personaje es nadador. Algunos jefes no son personajes.
No valid conclusion	2OO Algunos bañistas no son toreros. Algunos peleadores no son bañistas.
No valid conclusion	3AA Todos los celebrantes son aventureros. Todos los traficantes son aventureros.
No valid conclusion	3IA Algunos bomberos son ciclistas. Todos los pícaros son ciclistas.

Correct Responses

Ningún peluquero es mentiroso Ningún mentiroso es peluquero Algunos mentirosos no son peluqueros	3EA	Ningún peluquero es mayordomo. Todos los mentirosos son mayordomos.
Algunos obispos no son huérfanos	30A	Algunos obispos no son alpinistas. Todos los huérfanos son alpinistas.
No valid conclusion	3AI	Todos los braseros son ovejeros. Algunos maridos son ovejeros.
No valid conclusion	3II	Algunas monjas son lavanderas. Algunas embajadoras son lavanderas.
Algunos coroneles no son guerreros	3EI	Ningún guerrero es isleño. Algunos coroneles son isleños.
No valid conclusion	30I	Algunos leñadores no son basureros. Algunos huelgistas son basureros.
Ningún economista es juez Ningún juez es economista	3AE	Todos los economistas son espías. Ningún juez es espía.
Algunos bandidos no son políticos	3	Alguno- bandidos son piscadores. Ningún político es piscador.
No valid conclusion	3EE	Ningún pajarero es sabio. Ningún bromista es sabio.
No valid conclusion	30E	Algunos muebleros no son floristas. Ningún diputado es florista.
Algunos enemigos no son granjeros	3A0	Todos los granjeros son cazadores. Algunos enemigos no son cazadores.

Correct Responses	
No valid conclusion	310 Algunos lavaplatos son cuñados. Algunos limpiadores no son cuñados.
No valid conclusion	3E0 Ninguna bruja es modista. Algunas danzantes no son modistas.
No valid conclusion	300 Algunos veladores no son católicos. Algunos caballeros no son católicos.
Algunos carteros son pasteleros Algunos pasteleros son carteros	4AA Todos los vendedores son carteros. Todos los vendedores son pasteleros.
Algunos teólogos son jurados Algunos jurados son teólogos	4IA Algunos ayudantes son teólogos. Todos los ayudantes son jurados.
Algunos tesoreros no son ciudadanos	4EA Ningún sacerdote es ciudadano. Todos los sacerdotes son tesoreros.
Algunas comadres no son obreras	40A Algunas esposas no son obreras. Todas las esposas son comadres.
Algunos comerciantes son ganaderos Algunos ganaderos son comerciantes	4AI Todos los maestros son comerciantes. Algunos maestros son ganaderos.
No valid conclusion	4II Algunos anunciadores son griegos. Algunos anunciadores son compañeros.
Algunos viajeros no son carceleros	4EI Ningún herido es carcelero. Algunos heridos son viajeros.
No valid conclusion	40I Algunos invitados no son funcionarios. Algunos invitados son delegados.

Correct Responses	
Algunos contratistas no son ingenieros	**4AE** **Todos los donadores son contratistas.** **Ningún donador es ingeniero.**
Algunos pintores no son tontos	**4IE** **Algunos trapecistas son pintores.** **Ningún trapecista es tonto.**
No valid conclusion	**4EE** **Ningún molinero es ladrillero.** **Ningún molinero es mozo.**
No valid conclusion	**4OE** **Algunos autores no son plomeros.** **Ningún autor es mecánico.**
Algunos dictadores no son gendarmes	**4AO** **Todos los gobernadores son dictadores.** **Algunos gobernadores no son gendarmes.**
No valid conclusion	**4IO** **Algunos mineros son enfermos.** **Algunos mineros no son aduaneros.**
No valid conclusion	**4EO** **Ningún limpiabotas es niño.** **Algunos limpiabotas no son huéspedes.**
No valid conclusion	**4OO** **Algunos oficiales no son negociadores.** **Algunos oficiales no son traisioneros.**

* * * * * * * * * * *

SPANISH (DAY 2)

Correct Responses		
Todos los estudiantes son motociclistas. Algunos motociclistas son estudiantes. Algunos estudiantes son motociclistas.	1AA	Todos los estudiantes son deportistas. Todos los deportistas son motociclistas.
Algunos carniceros son penitentes. Algunos penitentes son carniceros.	1IA	Algunos carniceros son futbolistas. Todos los futbolistas son penitentes.
Algunos albañiles no son boxeadores.	1EA	Ningún boxeador es soldador. Todos los soldadores son albañiles.
No valid conclusion.	1OA	Algunos herreros no son artistas. Todos los artistas son alumnos.
No valid conclusion.	1AI	Todos los artesanos son divorciados. Algunos divorciados son lectores.
No valid conclusion	1II	Algunos dentistas son cocineros. Algunos cocineros son solteros.
Algunos mensajeros no son esclavos.	1EI	Ningún esclavo es curandero. Algunos curanderos son mensajeros.
No valid conclusion	1OI	Algunos payasos no son diseñadores. Algunos diseñadores son fotógrafos.
Ningún vaquero es filántropo. Ningún filántropo es vaquero.	1AE	Todos los vaqueros son aviadores. Ningún aviador es filántropo.
Algunas madrinas no son niñeras.	1IE	Algunas madrinas son enfermeras. Ninguna enfermera es niñera.
No valid conclusion.	1EE	Ninguna cajera es telefonista. Ninguna telefonista es joven.

Correct Responses

No valid conclusion.	1OE Algunos paisanos no son vecinos. Ningún vecino es músico.
No valid conclusion.	1AO Todos los alcaldes son prisioneros. Algunos abogados no son alcaldes.
No valid conclusion.	1IO Algunos sordos son zapateros. Algunos enanos no son sordos
No valid conclusion.	1EO Ningún ladron es bilingüe. Algunos marineros no son ladrones.
No valid conclusion.	1OO Algunos carpinteros no son pescadores. Algunos choferes no son carpinteros.
Todos los escritores son panaderos. Algunos panaderos son escritores. Algunos escritores son panaderos.	2AA Todos los $\overset{B}{\text{parientes}}$ son $\overset{A}{\text{panaderos}}$. Todos los $\overset{C}{\text{escritores}}$ son $\overset{B}{\text{parientes}}$.
No valid conclusion.	2IA Algunos impresores son profetas. Todos los extranjeros son impresores.
Ningún jardinero es charro. Ningún charro es jardinero	2EA Ningún vago es $\overset{A}{\text{charro}}$. Todos los $\overset{C}{\text{jardineros}}$ son vagos.
No valid conclusion.	2OA Algunos sindicalistas no son borrachos. Todos los limosneros son sindicalistas.
Algunos abuelos son ministros. Algunos ministros son abuelos.	2AI Todos los matemáticos son $\overset{A}{\text{ministros}}$. Algunos $\overset{C}{\text{abuelos}}$ son matemáticos.
No valid conclusion.	2II Algunos mayordomos son peluqueros. Algunos mentirosos son mayordomos.
Algunos guías no son farmacistas	2EI Ningún pianista es $\overset{A}{\text{farmacista}}$. Algunos $\overset{C}{\text{guías}}$ son pianistas.

Correct Responses

2OI Algunos alpinistas no son obispos.
No valid conclusion. Algunos huérfanos son alpinistas.

2AE Todas las hermanas son $\overset{A}{\text{cantantes}}$.
Algunas cantantes no son meseras. Ninguna $\overset{C}{\text{mesera}}$ es hermana.

2IE Algunos norteños son jornaleros.
Algunos jornaleros no son tabaqueros. Ningún tabaquero es norteño.

2EE Ningún isleño es guerrero.
No valid conclusion Ningún coronel es isleño.

2OE Algunos espías no son economistas.
No valid conclusion. Ningún juéz es espía.

2AO 2AO Todos los piscadores son bandidos.
No valid conclusion. Algunos políticos no son piscadores.

2IO Algunos cazadores son granjeros.
No valid conclusion. Algunos enemigos no son cazadores.

2EO Ningún vendedor es cartero.
No valid conclusión. Algunos pasteleros no son vendedores.

2OO Algunos teólogos no son ayudantes.
No valid conclusión. Algunos ayudantes no son jurados.

3AA Todos los $\overset{A}{\text{ciudadanos}}$ son $\overset{B}{\text{sacerdotes}}$.
No valid conclusion. Todos los $\overset{C}{\text{tesoreros}}$ son $\overset{B}{\text{sacerdotes}}$.

3IA Algunas obreras son esposas.
No valid conclusion. Todas las comadres son esposas.

Correct Responses

3EA
Ningún desertor es campesino.
Todos los turistas son campesinos.

Ningún desertor es turista.
Ningún turista es desertor.
Algunos turistas no son desertores

3OA
Algunos pasajeros no son gitanos.
Todos los empleados son gitanos.

Algunos pasajeros no son empleados

3AI
Todos los comerciantes son maestros.
Algunos ganaderos son maestros.

No valid conclusion.

3II
Algunos carceleros son heridos.
Algunos viajeros son heridos.

No valid conclusion.

3EI
A
Ninguna ciega es madrastra.
c
Algunas enamoradas son madrastras.

Algunas enamoradas no son ciegas.

3OI
Algunos contratistas no son donadores.
Algunos ingenieros son donadores.

No valid conclusion.

3AE
Todas las modelos son bailarinas.
Ninguna quinceañera es bailarina.

Ninguna modela es quinceañera.
Ningum quinceañera es modela

3IE
Algunos oficinistas son importadores.

Algunos oficinistas no son pistoleros

3EE
Ningún pintor es trapecista.
Ningún tonto es trapecista.

No valid conclusion.

3OE
Algunos dictadores no son gobernadores.
Ningún gendarme es gobernador.

No valid conclusion.

Correct Responses

Algunos porteros no son viudos.	3AO	Todos los viudos son bandoleros. Algunos porteros no son bandoleros.
No valid conclusion.	3IO	Algunos lavaplatos son cuñados. Algunos limpiadores no son cuñados.
No valid conclusion.	3EO	Ninguna bruja es modista. Algunas danzantes no son modistas.
No valid conclusion.	3OO	Algunos veladores no son católicos. Algunos caballeros no son católicos.
Algunos nadadores son jefes. Algunos jefes son nadadores.	4AA	Todos los personajes son $\overset{A}{\text{nadadores}}$. Todos los personajes son $\overset{C}{\text{jefes}}$.
Algunos toreros son peleadores. Algunos peleadores son toreros.	4IA	Algunos bañistas son toreros. Todos los bañistas son peleadores.
Algunos traficantes no son celebrantes.	4EA	Ningún aventurero es celebrante. Todos los aventureros son traficantes.
Algunos pícaros no son bomberos.	4OA	Algunos ciclistas no son bomberos. Todos los ciclistas son pícaros.
Algunos braseros son maridos. Algunos maridos son braseros.	4AI	Todos los ovejeros son braseros. Algunos ovejeros son maridos.
No valid conclusion.	4II	Algunos anunciadores son griegos. Algunos anunciadores son compañeros.
Algunas embajadoras no son monjas.	4EI	Ninguna lavandera es monja. Algunas lavanderas son embajadoras.

Correct Responses

4OI
No valid conclusion. Algunos invitados no son funcionarios.
Algunos invitados son delegados

4AE
Algunos leñadores no son huelgistas. Todos los basureros son leñadores.
Ningún basurero es huelgista.

4IE
Algunos sabios son pajareros.
Algunos pajareros no son bromistas. Ningún sabio es bromista.

4EE
Ningún molinero es ladrillero.
No valid conclusion Ningún molinero es mozo.

4OE
Algunos autores no son plomeros.
No valid conclusion. Ningún autor es mecánico.

4AO
Todos los floristas son muebleros.
Algunos muebleros no son diputados. Algunos floristas no son diputados.

4IO
Algunos mineros son enfermos.
No valid conclusion. Algunos mineros no son aduaneros.

4EO
No valid conclusion. Ningún limpiabotas es niño.
Algunos limpiabotas no son huéspedes.

4OO
No valid conclusion. Algunos oficiales no son negociadores.
Algunos oficiales no son traisioneros.

* * * * * * * * * *